The
ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

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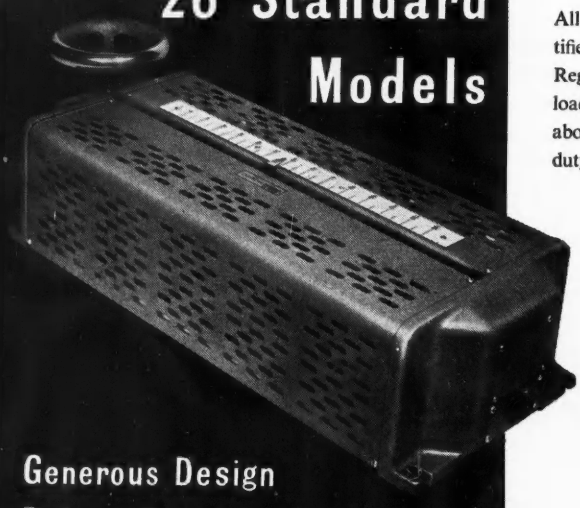

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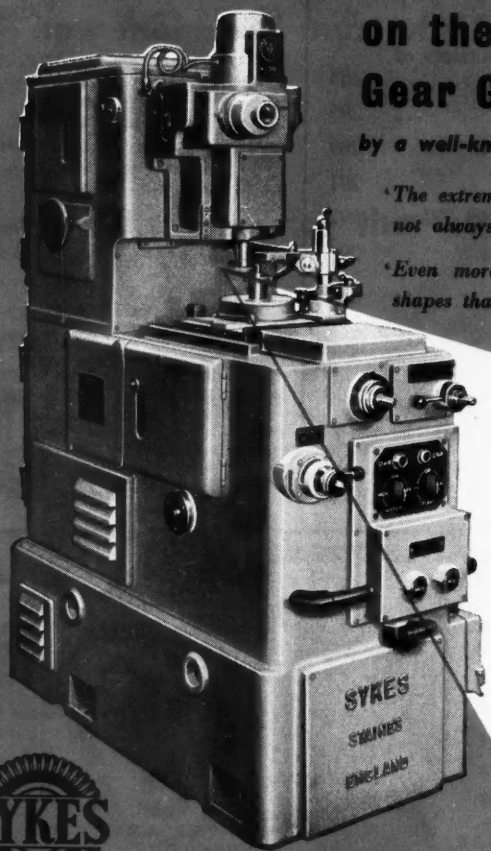

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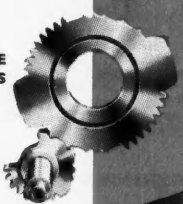

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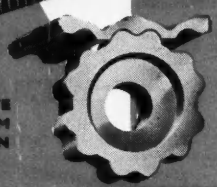

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THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *SPIN TESTING*

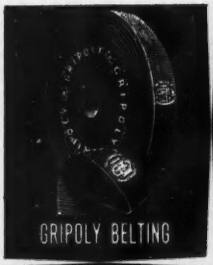
The design of turbo-machinery for greatly increased rotational speeds has led to considerable extensions in spin testing installations in the industries concerned. Particularly in the gas turbine industry, the introduction of new alloys has made it necessary to ascertain their deformation characteristics when subjected to high centrifugal forces. The rim and blading of these turbines operate at temperatures considerably above those prevailing at the shaft and central portions. In order to simulate these operating conditions, test stands have been equipped with special heating devices. In one particular instance, the heating apparatus consists of induction heating coils placed in such a position as to raise the rim and blade temperatures to between 1000 and 1500° F, while the hub and web are kept cool by a water jet. While the hot spin test is the most accurate method available for the stress analysis of rotors, the stress-coat method of indicating strain is also in use, the stress coat lacquer being applied prior to spin testing. Another interesting application of high speed spinning is found in supercharger manufacture. It has been ascertained that, by overspeeding the impellers of superchargers from ten to twenty per cent, prior to final machining, deformation of the impeller in actual service is minimised. By spinning the pieces prior to machining, it is thus possible to reduce the requirement for excess clearances between casing and impeller. The power requirements of a test pit can be greatly reduced by spinning the pieces in vacuum. At the same time, the decrease in friction obtained serves to reduce the temperature rise of the piece under test. An airtight test pit and a vacuum pumping plant are, of course, required for this purpose.

● *SIMPLIFIED BALL BEARINGS*

In general, antifriction bearings are precision items, using high-grade materials and close-tolerance machining, and the finished piece is correspondingly expensive. Cost, however, is a limiting factor in the selection of bearings for many purposes. For service where speeds are slow and loading is light, a bearing made with less finely finished surfaces and with wider tolerances may be capable of completely satisfactory performance. This requirement is now met by the development of a low-cost ball bearing, which is made from steel tubing on a single machine, to which both tubing and steel balls are fed. The machine resembles a two-spindle automatic screw machine and discharges completed bearings ready for simple heat-treatment. The bearings are placed on a special rack which holds them vertically. They are then immersed for 30 minutes in a carburising salt bath, which forms a carburised zone of 0·006 to 0·008 in. in depth. The bearings are then removed from the salt bath and quenched in a tank of water on which floats a 3-in. layer of oil. This provides a cushioned quench, ensures a brighter finish on all surfaces of the bearings, and deposits a protective oil film on the parts as they are withdrawn. Tests with these bearings are claimed to have shown excellent performance under the service conditions for which they are intended, and to have more than adequate service life. It is suggested by the makers that the use of this bearing could be extended to applications in many types of equipment where low speeds and light loading are conditions of service. As the entire bearing is made of plain carbon steel, it does not involve the use of any scarce alloying materials and its price should be correspondingly low.

● *SPECTROMETER FOR STEAM MONITORING*

An improved design of mass spectrometer has been placed on the market which, within its range, permits almost immediate measurement of any process-gas constituent to be made. Special maintenance features are claimed to ensure continuous operation, and automatic protective devices prevent damage to the instrument, which can monitor either a single component in a process gas stream continuously or several components alternately. Periodic scanning of a preselected group of masses can be performed automatically by means of an additional special program device. Scanning over the entire range of the instrument can be readily performed by the operator. Any molecular fragment within the range from mass 12 to 40 can be monitored with satisfactory separation between adjacent masses. Where separation is not important, the range is extendable to mass 80. Hydrogen or helium can be monitored by adding an accessory movable shunt to the analyser magnet. Electron bombardment and acceleration of molecular fragments are controlled by closely regulated electronic circuits, thus minimising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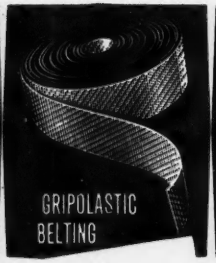
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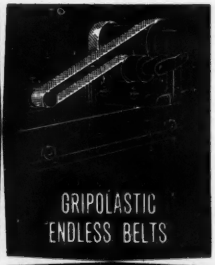
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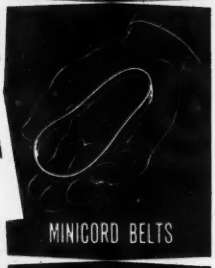
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variations in the mass spectra by possible changes in the operating characteristics of the instrument. A small flow of samples in the gaseous phase is supplied to the instrument at atmospheric pressure. In addition to monitoring the major constituents of a process, the instrument can also be used to monitor traces of impurities. By adding a hand-held probe for sampling the atmosphere, the apparatus can be employed as a highly sensitive indicator for locating and measuring leaks in pressurised systems. Hydrocarbons, sulphur compounds and other substances are readily detected. Traces of hydrogen and helium in a system can be detected by adding a special shunt to the analyser magnet system.

● *PUMPING PLANT CONTROL*

Water pumping plants which, for some reason, are not equipped with a gravity storage tank are usually provided with pressure control switch gear of conventional type, which puts the pumping plant in operation as soon as the pressure in the expansion chamber decreases below a predetermined level. It is reported that a new consumption pressure control system is now commercially available which ensures the maintenance of a favourable ratio of power consumption to water delivery, corresponding to the characteristics of the piping system for the various quantities consumed. In this system, the "on" and "off" pressures which control operation of the pumping plant are made to act upon a valve by means of which it is possible to keep operation of the system exactly in accordance with the characteristic curves of pipe line capacity. No special plant is required for this purpose and the type of pump employed in the usual pressure control systems is retained for the new control system. It is claimed that the consumption pressure control system affords considerable savings in power consumption for the delivery of small amounts of water. Where water consumption fluctuates widely, plant economy can be further enhanced by arranging several pumps to work in parallel during peak load conditions. For a water consumption of 20,000 gph, the saving in power consumption obtainable with the new control system is estimated to be 20,000 kWh per year, based on an operation of 8 to 10 hours per day, while for a consumption rate of 33,000 gph, the annual saving is estimated to be 30,000 kWh.

● *IMPREGNATION OF SINTERED PARTS FOR PLATING*

The porosity of sintered powdered metal parts is a serious handicap in cases where parts are to be plated. The methods employed hitherto to overcome this difficulty have proven either too costly or too complicated to warrant their use economically. In addition to plating problems, porosity has also prevented the general use of powdered metal parts in cases where the parts must be pressure-tight. A recently developed method of impregnating sinterings accomplishes the following three objectives: (1) The voids are permanently and invisibly filled, so that the parts can be successfully plated with no subsequent blemishes developing, such as blistering or corrosive reaction. (2) The impregnated parts are pressure-tight and will hold pressures of over 5000 psi. (3) Internal corrosion is prevented under any conditions. The material used to fill the pores is a thermosetting polyester-styrene copolymer. This plastic is inert, non-corrosive, and resistant to acids, alkalis, salt water, alcohols, glycols, gases, and all solvents. It has no effect on, nor is it affected by, any metal alloy. It withstands temperatures from —75° F to + 400° F. The impregnation process comprises the following steps: The parts are degreased, if necessary, and pre-baked at 250 to 300° F to remove all moisture from the pores. The parts are then impregnated with copolymer in pressure vessels under vacuum and pressure, so that complete pore penetration is attained. Impregnant is removed from all interior and exterior surface areas as well as from blind taps, threads, etc., in a special emulsifying cleaning bath. Finally, the parts are cured at 250° F to 300° F to polymerise the impregnant in the voids. A typical application is the treatment of sintered iron pinions and parts of business machines, prior to the cadmium plating of these parts.

● *A NEW 4500-PSI, 120-MW POWER PLANT*

A new boiler and turbo-generating unit, designed to operate above the "critical" pressure, has been announced recently. It will be the most efficient electricity generating unit ever built and will utilise the unprecedented steam pressure and temperature of 4500 psi and 1150° F respectively. The turbine, which will be of over 120 MW capacity, will thus operate at almost double the highest steam pressure at present used in power production. The initial steam temperature of 1150° F will be 50° F higher than the present maximum and will be followed by two stages of reheat, the first at 1050° F and the second at 1000° F. The boiler will be of the "once-through" type, with a feed water-pump designed for a pressure of 5500 psi. The boiler will be equipped with cyclone furnaces. Many new ideas in turbine, boiler, and plant design will be incorporated and tested in this development which, it is hoped, will open the way to still more advanced steam conditions. This should not only establish new world standards for efficiency in generation of steam-electric power, bringing within reach thermal efficiencies of the order of 50 per cent, but should ultimately make possible reductions in capital cost, by reducing the size of units and bringing about more efficient utilisation of materials.

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● *ELECTRIC MOTORS FOR LINEAR MOTION*

Under the influence of the considerations involved in large power production, almost the entire development of electrical machinery is governed by the aspect of rotary motion, and very little attention is given to power mechanisms for the direct production of linear motion. Wherever linear motion is required and hydraulic power cylinders are not suitable or acceptable, rotary motion produced by electric motors is converted into linear motion by an appropriate mechanism. Nevertheless, there remains a small range of applications, particularly in the field of automatic control gear, where fractional horsepower drives producing direct linear motion can be used to advantage. Compared with a rotary drive combined with linear motion mechanism, the direct linear drive offers the advantage of quicker starting and stopping owing to its inherently smaller inertia. The devices so far developed are of the electromagnetic type, employing a stationary field and a reciprocating armature, but other linear devices can be visualised, including those employing electrostatic principles. It is obvious that in a device where rectilinear, or nearly rectilinear, electromagnetic attraction forms the operating principle, power strokes must alternate with return strokes. In order to produce unidirectional motion of the output member, which may be designated as the power rod, the mechanical linkage or coupling between the reciprocating armature and the power rod must therefore be broken during the return stroke. In the mechanisms referred to, this is accomplished by friction couplings, by means of which a reciprocating drive member is connected to the power rod during the power stroke and released during the return stroke. Electromagnetic devices of this type have been developed for direct current and alternating current, including three-phase operation, and are available with unidirectional pulls as large as 220 lb and developing the power equivalent of 70 W.

● *MEASURING GAS TURBINE BLADE TEMPERATURE*

The urgent need to increase the operating temperature of gas turbines to make them competitive with other prime movers, particularly diesel engines, confronts the turbine designer with formidable problems. Considerable efforts are now being made to solve the high temperature problem by the employment of internally cooled blading. Unfortunately, the actual temperature distribution in an internally cooled rotor blade is difficult to determine by calculation in view of the many factors involved, and experimental determination must therefore be resorted to. Attempts have been made to coat blades and rotor with temperature-sensitive pigments, the discoloration of which can be used as a measure of the temperature prevailing. While this method gives excellent results where stationary parts are concerned, the high speeds involved in rotor operation make it difficult to prevent the paint from flaking off. The introduction of thermocouples into the blade itself is of course possible, but meets with considerable practical difficulties; furthermore, it requires the provision of special sliprings for the electrical connection. A promising solution appears to lie in the employment of a special pyrometer, which incorporates a concave mirror system to collect and reflect the heat radiation received from the point under observation. Although the mirror is kept at a suitable distance from the rotor blading, it is nevertheless exposed to the combustion gas atmosphere, although the gas temperature is kept low at the point where the gas reaches the mirror. Considerable difficulties were therefore met owing to the tarnishing of the mirror by the gases, but rhodium-plated mirrors were finally found to give satisfactory service. The mirror reflects the heat rays upon a special type of thermo-element, which consists of 30 small thermocouples arranged in series within a circle of 5 mm diameter. It is reported that temperatures up to 800° C can be measured by this method with an accuracy of $\pm$ 5° C.

● *FABRICATION OF SMALL-BLADED ROTORS*

The fabrication of small-bladed rotors for rotary power conversion machines (e.g., axial flow compressors or turbines) may present a difficult problem. Conventional practice, at least in the larger sizes, involves the separate attachment of the individual blades to the rotor disc by the engagement of suitably shaped root portions in "fir-tree," or other undercut, peripheral recesses; in the case of relatively small discs, it may well be impracticable to provide, around the periphery, the requisite numbers of retaining recesses. To meet this difficulty, the blades of small rotors have sometimes been formed integrally with the discs by which they are carried; in the smaller cases, the proximity of adjacent blades may make it difficult to enter machine tools between the blades. According to a recent proposal, equidistantly spaced blades are formed integrally around a rotor disc and the rotor is completed by the individual attachment of separately fabricated blades in the spaces between the integrally formed blades. In one example, alternate blades may be formed integrally, the intermediate, separately fabricated blades being attached in conventional manner, e.g., by means of undercut recesses; in another example, every third blade may be formed integrally, a pair of blades, with complementary root portions, being mounted in a common undercut recess formed between each pair of adjacent integral blades.

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● *SINTERED COMPONENTS WITH WEAR RESISTANT SURFACES*

A recent patent envisages a new method for the production of wear-resistant working surfaces on machine parts made from powdered metal, as, for instance, gear wheels. This method aims at providing such parts with working surfaces of considerably greater strength than can be achieved by ordinary compacting and sintering of iron and steel powder. The main interest attaches to the feature that the wear-resisting working coating is applied to the part during or after its compacting. The wear-resisting coating may be applied galvanically or by spraying and may, for instance, consist of chromium. In cases in which the thermal consolidation of the powdered metal part is effected by pressure sintering, it is claimed to be advantageous to apply the coating after cold pressing in order to obtain, during subsequent pressure sintering, an intimate bond by heat diffusional stress equalisation between the coating and the foundation body. Where applicable, a thin sheet metal strip of weldable high wear resistant material may be used as a coating. Where, for example, a wear resistant coating is to be produced on a cam, a sheet metal strip is bent to conform to the contours of the cam. The breadth of this sheet metal ring is made to correspond to the final thickness of the cam. This ring is slipped over the compact, which is then inserted in the mould for pressure sintering; analogously, in the case where the cam has been previously sintered without pressure, the piece with its wear resistant ring is subjected to hot pressing. Owing to the radial pressure produced during the pressing, the ring will be bonded to the cam, and this effect may be assisted by the application of a flux.

● *HIGH STRENGTH ALUMINIUM CONDUCTORS*

For rotating electrical machinery, a conductor metal is desired which combines high mechanical strength with high electrical conductivity; this requirement is particularly important in the case of field windings for alternators driven by high-speed turbines. Aluminium conductors have been used in the past because of their favourable ratio of weight to electrical conductivity, making it possible for the designer to plan high-speed rotors of larger diameter and therefore of greater capacity than is possible with copper windings. This is especially important in America, where the speed of two-pole machines for 60 cycles is 3,600 rpm as compared with 3,000 rpm for 50 cycle machines. The conductors are placed in slots of the rotor forging where, under certain operating conditions, the compressive stresses produced by restrained expansion may be sufficient to cause progressive plastic deformation of the aluminium. Considerable efforts have been made to develop a more suitable grade of aluminium which would exhibit greater rupture and tensile properties, higher recrystallisation temperature and resistance to creep at operating temperatures. The alloy finally selected is reported to contain 0·43 per cent iron, 0·32 per cent magnesium and 0·1 per cent silicon as alloying constituents. Although the magnesium and silicon contents are too low to yield any major improvement by heat treatment, it was found possible to age the cold-worked material at 390° F. This alloy could therefore be accepted by the makers of electrical machinery as a satisfactory high-strength, low-creep, high-conductivity aluminium. The electrical conductivity of the new material is stated to range from 58·5 to 60 per cent of the International Annealed Copper Standard. In the aged condition, this aluminium alloy has been used in a number of the largest alternators in operation today.

● *BLISTERING OF ENAMELS*

A recent research report contributes valuable information on the problem of blistering in cast iron enamels. It is proved that in certain cases such blistering may be due to gases evolved from the metal. When enamelling above 680° C, reaction occurs between iron oxide and carbon, and gases may be generated in sufficient quantity to bubble through the enamel. If the reaction has virtually ceased when the enamel is in its most fluid state, good results will be obtained, but if the reaction continues to any extent at the maximum temperature and during subsequent cooling, blistering defects will be apparent on the finished ware. In this type of blister formation, the source of blistering gases depends upon iron oxide, which has been formed in the pre-fusion period. There is good reason to believe that another source of trouble is the absorption of moisture, which causes sub-surface rusting of the casting. During annealing, oxidation of the surface occurs, and if this operation is prolonged, oxide penetration can occur. Subsequent shot blasting will remove the surface scale more easily than it would remove rust, but penetrating oxides cannot be removed and may prove to be serious causes of blistering. Practical evidence seems to show that too much importance cannot be attached to speed of operation either between casting and enamel fusing or between annealing and enamel fusing. As the report points out, compatibility of the enamel with the iron has to be considered and this explains frequently occurring instances of castings which cannot be enamelled successfully in one plant and yet can be enamelled successfully in another.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.

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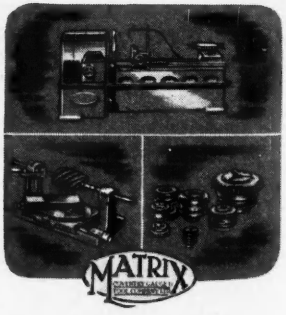

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Applied Research at Extremely Low Temperatures

In the extreme low-temperature range, some extraordinary phenomena have been observed. The following abstract from a series of articles issued by Arthur D. Little, Inc., of Massachusetts, discusses these phenomena and their practical applications, particularly in connection with the superfluidity of helium and the superconductivity of metals.

THE field of cryogenics is expanding so rapidly that, unless one is actually working in this relatively new field, it is difficult to keep abreast of current developments. Until recently, fundamental studies at extremely low temperatures were made by only a few laboratories, mainly because the equipment available for low temperature production was unreliable and hard to manage. However, with the current development of efficient and easily controlled apparatus, this new field of research is now available to any laboratory.

The extreme low-temperature range may be taken as referring to temperatures between approximately — 300° F (90° K) and — 460° F (absolute zero or 0° K), and more particularly to the region below — 406° F (30° K). Many of the recent findings of research in this range have practical applications in the fields of chemistry, electronics, and metallurgy, some of which are summarised below.

APPLICATIONS IN CHEMISTRY

A knowledge of the properties of substances in the low-temperature range is essential to the understanding of the chemical nature of matter, for it is knowledge that comes unobscured by the effects of thermal agitation. In short, at low temperatures, the properties of the atom or crystal, and not the properties of thermal motion, can be studied.

Knowledge of chemical behaviour at low temperature has been found particularly valuable to the chemist as a key to the understanding of high-temperature reactions. One example of this is the accumulation of data on the thermodynamic functions of chemical substances, particularly the entropy and enthalpy which determine whether certain substances will react with each other. The measurement of the entropy of a substance is carried out by determining its heat capacity as a function of temperature to as low a temperature as practical and then extrapolating to absolute zero, where the entropy of all substances, according to the third law of thermodynamics, is zero. Thus, from low-temperature calorimetric measurements, the lowest temperature at which a reaction can take place, as well as the best operating conditions (temperature, pressure, relative amounts of ingredients) and yield can be determined. For instance, it can be shown that the manufacture of artificial diamonds from graphite is possible only at high temperatures and pressures, so that attempts to create diamonds near room temperatures are doomed to failure. Other more complex reactions are currently being studied. In particular, considerable research along these lines is being carried out on the chemistry of phosphate compounds, with a view to producing more effective fertilisers.

It is always a problem in heat capacity measurements to decide on the lowest temperature from which it is safe to extrapolate the data to absolute zero. In some cases, such as with hydrogen, anomalous effects occur below 12° K, requiring measurements to be made in the liquid helium range. Methods of adiabatic demagnetisation may be necessary to investigate anomalous behaviour in the region below 1° K.

Low-temperature technique is promising in the control and stability of chemical reactions. As the temperature is lowered, thermal motion ceases and chemical activity decreases. Thus, chemists working at low temperatures are able to obtain a " slow-motion " picture of how a chemical reaction takes place. In investigating a reaction mechanism, it is often necessary to isolate and identify intermediate products of the reaction. This is frequently difficult, or impossible, because many of these are extremely unstable. A reaction quenched in liquid helium, however, should preserve these intermediate products and make their identification possible by such methods as absorption spectroscopy.

Here again, low temperature plays an important role. Often the analysis of complicated mixtures by absorption spectroscopy is rendered difficult because of the width and overlap of the absorption bands. As a general rule, however, absorption spectra become quite sharp, due to a reduction in natural band width, as the temperature is lowered to liquid helium temperatures. This has been found particularly valuable, for example, in determinations of characteristic vibrational frequencies of polyatomic molecules.

The materials normally used in chemistry are usually stable at room temperature. However, there is a whole series of chemicals, such as the free radicals and fragmentary molecules, which are not stable at room temperature. It would appear that many of these may be controlled at extremely low temperature, so that a new field of chemistry may well be opened up.

Extremely low temperature may also hold the answer to the problem of storage of highly reactive chemicals, as corrosion and oxidation of metals can be completely checked. Also, it seems possible that helium chilling will greatly increase the longevity of certain radioactive chemical elements produced by nuclear fission.

Furthermore, in the laboratory, it may often be more convenient to handle gases or volatile substances in the solid state.

Fundamental information, valuable in clarifying conflicting theoretical concepts, is being obtained from studies of the unusual properties of liquid helium itself. Helium, the gas with the lowest critical temperature, liquefies at — 452° F (4·5° K). Below 2·19° K, however, helium enters a new state which, as it does not resemble a solid, liquid, or gas, has been termed a fourth state of matter. In this state, it has an unusually high thermal conductivity, about 200 times that of copper at ordinary temperature and about 3 million times that of liquid helium above this transition temperature. It has an exceedingly low viscosity, which to a point decreases with temperature decrease. It will seemingly defy gravity by creeping up and over the walls of its container, and it is able to flow through tiny apertures, apparently without even the slightest friction.

One of the uses to which this property of superfluidity is being put is as a means of concentrating the rare isotope helium 3, since only helium 4 takes part in this super-flow. Study of the isotopic constitution of helium gas has previously been hindered by the fact that naturally occurring helium contains at most a He^3/He^4 ratio of 12×10^{-7}, with no convenient means of concentration.

At absolute zero, helium appears to be the only substance that would not be in the solid state. At about 25° K, all substances except hydrogen, deuterium, tritium, neon, and helium are solids. More particularly, the first two are in the liquid state and their separation from one another should be feasible by fractional distillation, with a considerably lower expenditure of energy than by the present electrolytic process. Also, the preparation of pure para-hydrogen and ortho-deuterium is easily accomplished at low temperature, making possible the availability of large amounts of these substances for research and industrial use. Furthermore, for the production of exceedingly pure samples of these low-boiling gases, all that is necessary is to liquefy them and collect a portion of their vapours, The gases produced are necessarily free from water; hydrogen is, in addition, free from all possible contaminants except helium; and helium gas generated from its liquid is fundamentally free from any impurities. While the value of high-purity products in research is obvious, these pure gases are also finding much commercial application. For example, liquid nitrogen is being used as the source of nitrogen gas for a protective atmosphere in alkyd resin production.

Magnetic measurements at low temperatures are receiving increasing attention by chemists because of their value in helping to explain the structure of complex organic and inorganic compounds. The susceptibility of paramagnetic substances is inversely proportional to temperature, and consequently, measurement of this important quantity at low temperature is practically a matter of course. One recent line of endeavour has been an attempt to correlate magnetic susceptibility with catalytic activity. Such correlation would be of fundamental importance in revealing the mechanism of catalysis.

Catalytic research is also intimately connected with research on surface states. Liquid helium is a unique tool for this purpose, since the rate of creep of superfluid helium is a function of surface condition. Furthermore, at liquid helium temperatures, all substances, except helium, are solids with completely negligible vapour pressures. Thus, a liquid helium trap would act as a very fast vacuum pump, producing excellent vacua and precluding the contamination of active catalyst surfaces. A similar scheme, using liquid hydrogen traps, could be used in gas analyses where low-boiling gases, such as carbon monoxide, are to be separated from helium.

Other extremely low temperature studies of chemical interest, currently being carried out, include investigation of the phosphorescence of organic materials, fluorescence emission spectra of halides, dielectric constants of long-chain fatty acids and their derivatives, and the photographic process.

The progress of both science and industry requires a continual flow of new and more accurate data, together with information on substances and properties little explored. Low-temperature chemical research will undoubtedly continue to supply much of this in increasing amounts, with facilities for cryogenic work becoming an integral part of every well-equipped laboratory.

APPLICATIONS IN ELECTRONICS

The strange properties of matter at temperatures in the region near absolute zero have been the object of much research in recent years. The general effect of low temperature is the production of ordered states of matter. If, at ordinary temperatures, something occurs with an energy smaller than several hundredths of an electron volt, it is swamped by the random agitation of the world about it, caused by thermal motion. Thus, at normal temperatures, a lower limit is set on the energy range of phenomena which may be reached. With a means of isolation from the energy of the outside thermal motion, the entire range of low-energy phenomena may be reached.

Outstanding among phenomena observed at very low temperatures is the conversion of certain metals and compounds into perfect electrical conductors. This phenomenon of super conductivity is of sufficient importance to the practical engineer to be considered in some detail. The fact that electrical resistance is proportional to temperature is to be expected from theory. On this principle, then, the resistance of pure metals should gradually decrease to zero at absolute zero, and this is what happens with the best of normal-temperature conductors, such as copper and silver, in their pure state.

In the case of other metals, including some which are poor conductors at ordinary temperatures, their resistance vanishes completely at some critical temperature above absolute zero. The electrical resistance of practically all metals has been investigated down to about 1° K or lower and, in all, about twenty metals so far have been found to be superconductive. For the most part, these lie in a well-defined region in the Periodic Table and include, among others, mercury, tin, lead, aluminium, and zinc.

In the extreme low-temperature range, the intermetallic compounds of bismuth and nickel, and of gold and bismuth, become perfect electrical conductors, although the components themselves are not superconductors. This is also true of the semi-metallic compounds, cupric sulphide, the molybdenum carbides, and the tungsten carbides. In many cases, an alloy becomes superconductive at a temperature lower than the transition temperature of either of the individual metals. The highest temperature at which superconductivity has been found is 15° K with columbium nitride.

Although superconductivity is not fully understood theoretically, it has already found application in bolometers, or radiant energy detectors. The two desirable qualities in bolometers are speed and sensitivity. At room temperature, thermal fluctuations, or Brownian movement of the electrons, places a limit on bolometer sensitivity. This limit can be effectively removed by lowering the temperature, thereby reducing Brownian movement. Briefly, the sensitive element is a superconducting strip of metal maintained in the transition range between normal and superconductivity, where a slight change of temperature will cause an enormous change in electrical resistance. For example, the resistance of tin was found to decrease gradually with temperature down to 3·70° K; at this point the resistance dropped so sharply that 50 per cent was lost in the next 0·0001° K. Furthermore, low-temperature operation guarantees rapid response by virtue of the low heat capacity, and also a low ultimate limit of detectability, resulting from the low level of noise caused by statistical fluctuations.

Many bolometers using columbium nitride as the sensitive element have been studied. An improvement in speed by a factor of one hundred, over bolometers operating at room temperatures, has been obtained in practice, and it has been found possible to detect changes in temperature as small as 0·0000001° C. In fact, neglecting atmospheric absorption, which can vary over wide limits, the superconducting bolometer is sufficiently sensitive to detect the heat of a candle at a distance of 25 miles.

Dr. Andrews, at John Hopkins University, who has done considerable research on superconducting bolometers, has suggested a number of possible applications: For example, when used with an oscillating scanning mirror, the bolometer can pick up images of objects by their own thermal radiation and present crude pictures of the objects on a television screen. If installed inside a warehouse, the bolometer would be able to detect an intruder in complete darkness, transmit the picture by wire for an almost unlimited distance and present the picture on a television screen at a central station. Similarly, any temperature difference, even as little as a few degrees, developed by spontaneous combustion or any sort of abnormal heating, could be detected and shown on a TV screen at some distant point. Experiments have also been carried out in the scanning of the external walls of a building, where imperfect thermal insulation caused temperature differences. These showed up immediately in the picture of the building appearing on the screen.

A superconducting bolometer was also found to be a detector of radio signals, necessarily superior to other types of radio receivers operating at room temperature in its signal-to-noise ratio. More practical interest is being attached to the fact that the superconductive bolometer can be used as an alpha particle detector, which not only counts the particles but gives an indication of the energy.

The magnetic properties of superconductors are fully as important and unexpected as are the electrical properties. The magnetic permeability of a metal in the superconductive state is zero; in other words, a superconductor is perfectly diamagnetic. Thus, superconductors become, among other things, excellent magnetic shields. With such a shield, magnetic noise in the atmosphere may be completely excluded from a region.

Superconductivity also offers a means of constructing magnetometers of high sensitivity and low noise. High Q resonators are available in the form of cavities made from superconducting material. Q's in range of millions have been reached. Because the metals have vanishing expansion coefficients at low temperatures and become exceedingly stiff and rigid, the mechanical stability of these resonators is great. Electrical filters composed of elements made of superconducting metals would possess properties unattainable by other means.

Recent experiments have shown that a superconducting lead sphere can be placed in rotation and suspended in space by a suitable arrangement of coils. This is a truly frictionless suspension, since eddy current effects can be eliminated, leaving only the friction due to the helium gas necessary to keep the sphere in thermal contact with the surrounding liquid helium. The sphere is supported by the magnetic field of persistent currents induced in the superconducting coils. Repulsion results from the interaction of surface currents on the sphere with the field of the rings. It was suggested that this might be utilised in the realisation of a massless support or suspension for moving parts of measuring instruments. At present, it has found application as a means of measuring the viscosity of gaseous helium in the neighbourhood of 4·2° K.

Another subject of potential interest to electronics workers is the temperature dependence of electrical noise. The ordinary noise found in metallic resistors, referred to as Johnson or thermal noise, is known to decrease in direct proportion to the temperature and to increase with the value of the resistance used. Thus, when thermal noise in a resistor is of great importance, a considerable increase in the signal-to-noise ratio can be expected by making it of metal and lowering the temperature.

Photoconductors, substances which react to light by changing their electrical conductivity, are limited in sensitivity by thermal noise, which may be removed with liquid helium.

The field of semi-conductors may also benefit from low-temperature measurements or processes. Admixtures of alloying materials markedly affect the conductivity of germanium, and the effect is different at very low temperatures than at room temperatures. It is felt that additional data obtained in extreme cold should help to explain the conductive mechanisms of germanium and thus improve semi-conducting devices such as germanium diodes and transistors. Perhaps a material, as yet undiscovered, may show semi-conducting properties at liquid helium temperature and may be useful as a low-noise transistor.

Insulators become so nearly perfect at these low temperatures that they may hold a charge for unusually long periods. This may be useful, for example, in a storage tube for computers.

The magnetic properties of matter are greatly changed, or at least exaggerated, at low temperatures. The fact that nuclear and paramagnetic resonance at radio and microwave frequencies becomes sharp and strong should be useful in filters, timing circuits, etc. The rare earth salts, which exhibit low loss ferromagnetics, unusually high permeabilities, and other such properties, await application in devices such as magnetic amplifiers.

In current cryogenic research, liquid helium plays a dual role. In addition to its use as a low-temperature bath, the properties of liquid helium, such as superfluidity, heat conduction through wave motion, and production of mechanical work from thermal excitation without external "engines," are so spectacular that an alert research team should find many uses involving them. A thermal delay line, perhaps, could be fashioned from the low-velocity second sound propagation in liquid helium.

Physical literature contains many examples of low-temperature effects and phenomena, which have hitherto been unexploited for useful purposes owing to the difficulty of obtaining liquid helium. New practical developments of these effects are now only a question of time and study.

APPLICATIONS IN METALLURGY

Cryogenic research is important to the metallurgist in two general respects: Firstly, to find out how the common engineering metals and alloys behave when subjected to extremely low temperature. Secondly, and perhaps of even greater importance, is the contribution of low-temperature research to the understanding of the fundamental rheological properties of metals, the clue to their behaviour at high temperatures. This type of study is of particular value in the processing of metals.

The martensitic transformation has been the subject of much controversy. It is generally agreed that the reaction involves a nucleation process which requires activation and that the activated nuclei develop into the well-known martensitic plates with tremendous speed. However, various theories have been proposed to describe the nature of the nucleus and the mechanism by which the nucleus propagates. Plastic deformation and straight cooling experiments, using several commercial steel specimens at temperatures approaching absolute zero, have revealed much valuable data on this problem, indicating that the steel hardening process involves a co-operative shearlike sliding of many atoms moving in unison, rather than individual movements of the atoms. More specifically, this research shows that large amounts of this transformation could occur even at liquid helium temperatures, where all such processes in metals have previously been assumed to come to a complete stop. Indeed, in some types of steel, the amount of martensite produced was nearly 100 per cent at this low temperature, whereas very little was formed at room temperature. In others, hardening did not begin until a temperature of — 240° F (122° K)

was reached. The practical advantages to be gained by low-temperature steel hardening are obvious, but more important, quantitative predictions can now be made of the behaviour of steel treated in various processes.

The problem of phase changes in solids at low temperatures in general is receiving much attention. The energy balance which decides whether a crystalline lattice is to be closely packed hexagonal or face centred cubic, for instance, is very slight, and it is believed that much can be learned about the properties of a substance by studying its phase changes in detail.

Studies of plastic flow and strength of metals are being extended to extremely low temperatures with interesting results. It is found that most substances become less plastic and stronger as the temperature is lowered. The remarkably clear tone of a lead bell at temperatures near absolute zero is a good example of this fact.

The danger of extrapolating existing data on the mechanical properties of metals to lower temperatures was emphasised in recent work on carbon steel, which showed an unexpected transition from the brittle to the plastic state as the temperature was lowered to about — 350° F (61° K). There is no reason to believe that steel is unique in possessing unusual characteristics.

More basic low-temperature research in the field of metals is being carried out on the effect of imperfections on " perfect " crystal behaviour. In this respect, the electrical resistance of metals and alloys at low temperatures is important. The distinguishing feature of a metal is not so much the strong interatomic forces which hold its atoms together as the fact that each of these atoms is likely to lose control over one or more of its electrons. These electrons then belong to no single atom and, driven by thermal agitation, are free to wander about inside the metal with certain restrictions. The guided wandering of these electrons causes a net current to flow when an electric field (or potential difference) is put across the metal. The electrons do not lose energy to the atoms if they are arranged in a perfectly regular lattice; thus, if nothing else had to be considered, infinite conductivity could be expected.

However, lattices are not perfect in practice and are usually distorted. The lattice is being continually agitated by the thermal vibrations of the atoms, and these vibrations can interact with the electrons and

(*Concluded on page* 314)

GERMANY

Ignition Phenomena in Diesel and Gas Engines

By M. LEIKER. (From *Motortechnische Zeitschrift*, Vol. 14, No. 6, June, 1953, pp. 161-174, 20 illustrations.)

THIS article deals with the combustion processes occurring in engines operating on diesel fuel, petrol, gas, and gas-and-liquid fuel mixtures. The first part reviews definitions and formulae related to ignition delay, and to cetane and octane numbers, air/fuel and air delivery ratios, and combustion velocity. It includes tables with numerical data for various fuels (ranging from fuel oil to generator gas and blast furnace gas) with specific weights, percentage volume of constituents, gas constants, theoretical amount of air required, lower calorific values of fuels and mixtures, composition of burnt gases, etc. Various expressions are given for air/fuel ratios and calorific values of mixtures for engines operating on different fuels, with diesel or petrol engine cycles.

The second part of the article sets out the results of tests on diesel, petrol and dual-fuel engines, with a large number of indicator diagrams and graphs relating to engine performance, and the results are compared with those of other investigators.

Compression-ignition tests: Tests were made on a Deutz T2M425 two-stroke engine specially designed for operation with various fuels. Tests at 600 rpm were carried out on fuel oil, benzine, and low-grade fuels. The corresponding cylinder pressure diagrams showed that high cetane fuels reach lower peak pressures than low grade fuels and that low grade fuels produce large-amplitude fluctuations in the cylinder pressure diagrams in the expansion period, owing to the appreciable ignition delay of these fuels. The ripples increase with reduced values of imep. Improvements in running smoothness with low-grade fuels and gaseous fuels are obtained by additional injection of fuel oil and preliminary heating of boiler fuels. With four-stroke diesel engines, supercharging improves running smoothness, owing to the correspondingly higher values of compression temperature and pressure, which reduce the ignition lag and result in a more gradual pressure rise during combustion.

External ignition tests: The Deutz T2M425, with a compression ratio of 14:1, was used as a petrol engine, with external ignition. The peak pressures in the indicator diagrams were decreased when exhaust gas was added to the intake air. The engine was then operated on town gas. Irregular ignition and increased consumption were obtained at partial loads.

Mixed-fuel operation: A Deutz VMV145 four-stroke engine with direct injection, running at 300 rpm, was used for these tests. After modification, the engine was run on mixtures of generator gas and fuel oil. It was found that with these mixtures the indicator diagrams showed greater ignition delays and steeper slopes than when the engine was operated as a pure diesel engine. At part loads, consumption was less favourable. At full load, however, the results in some cases were even better than those for a diesel engine. Four-stroke engines with mixture control are regarded as a simple and suitable solution.

The T2M425 two-stroke engine was then tested with very lean gas-and-air mixtures, using a compression ratio of 15·4:1. Operating on fuel oil and town gas, it was found that the consumption of liquid fuel decreased immediately when even very small quantities of gas were mixed with the scavenge air. However, the knock tendency increased, particularly at part loads. The best results were obtained with 7·7 per cent gas in the mixture, giving better consumption figures than for pure diesel operation. Additional tests were made with methane and fuel oil, using the same engine. The cylinder pressure diagrams and general results were similar to those obtained in the previous case.

Liquid-gas and fuel oil tests: A propane-butane mixture, expanded to 1 atmosphere gauge pressure, was used in an after-charging process, which was tried out on the two-stroke engine. The consumption of fuel oil dropped to half the normal value. Tests on propane-butane without fuel oil resulted in violent self-ignition effects, which were clearly indicated in the diagrams.

The investigation shows under what conditions it is possible to operate a modern multi-fuel type engine and it is concluded that in many cases the two-fuel engine is preferable to the petrol engine, and even to the diesel engine for certain applications, as, for instance, marine propulsion engines operating on generator gas, power plants in petrol-producing areas, power plants for clear gas and pure methane operation, and diesel plants with short overload periods.

The Interpretation of Film Formation on Commutators of D.C. Machines

By L. D. Cook. From *Iron and Steel Engineer*, Vol. 30, No. 6, June, 1953, pp. 74-83, 10 illustrations.)

Although the fundamentals relative to the correct electrical and mechanical adjustments necessary for good commutation on d.c. machines are well known, valuable information may be derived from observation of the quality and texture of commutator skin or film, as a means of diagnosing troubles in d.c. machines and ensuring their efficient operation.

An analysis of the film on commutators of d.c. machines shows this film to be composed of copper oxides and brush material, plus a trace of dust particles captured from the atmosphere. The total thickness of this important layer is only a few millionths of an inch, and this accounts for the difficulty often experienced in maintaining the desired commutator films, particularly at the higher operating speeds. This film has lubricating ability, enabling brushes to operate at relatively low friction and wear. This lubricating property has been shown to be due to a layer of water molecules adhering to, or absorbed on, the surfaces of graphite or carbon crystals at the surface of the film. The source of the water is the moisture normally contained in the atmosphere, and the absence or reduction of this water will bring about very high brush friction and exceedingly rapid wear.

The process of film formation is the result of a continual deposit of brush material by the negative brushes (on a generator) and the oxidation of copper at the contact surface. While the negative brushes are in the process of depositing material, the friction of the positive brushes is continuing to remove it. As the layer becomes thicker, its removal by the positive brushes becomes proportionately greater, until a point of equilibrium is reached and the film becomes stationary. After this, the quality and thickness of the film may pass through wide variations, caused by any number of outside influences. Sufficient film to provide for a normal operating friction and contact drop is completely formed in about 80 minutes at a peripheral speed of 5000 fpm. However, the point of equilibrium or stabilisation may not be reached until after 10 days or more of operation.

Relative Merits of Film Thickness

The quality and the degree of thickness at which the commutator film becomes stabilised is of vital importance to brush performance. Therefore, when brushes are selected for a machine, the quality of film best suited to the machine in question, together with a knowledge of how this film may be obtained, should be understood. In some cases, the chocolate brown film so often referred to in the descriptive literature of carbon manufacturers may produce the desired results, but unfortunately this is not always the case. To clarify this subject, the beneficial or deteriorating effects that may result from a commutator film stabilised too soon (thin or light-coloured film) or stabilised too late (thick or dark film) are listed for comparison :—

Beneficial effects that may be expected from a thick, dark film are : (1) Low friction ; (2) high contact drop ; (3) long brush life ; (4) minimum commutator wear.

Deteriorating effects that may be expected when the film is too thick are : (1) High commutator temperatures ; (2) copper picking and streaking ; (3) high friction and brush chatter ; (4) short brush life ; (5) sparking and bar burning at the leaving edges.

Beneficial effects that may be expected from a thin, light film are : (1) Low commutator temperatures ; (2) low friction ; (3) satisfactory brush life ; (4) smooth brush operation.

Deteriorating effects that may be expected when the film is too thin are : (1) Rapid commutator wear ; (2) short brush life ; (3) high friction ; (4) excess commutator maintenance (e.g., grinding and undercutting).

There are no predetermined rules governing the ideal film to be desired for a given application, and no personal preferences should be made as to whether a chocolate brown, or some other colour will prove the most satisfactory. Bearing in mind the beneficial and deteriorating effects that may result from film variation as listed above, the following specific examples will illustrate the point : On a well-adjusted machine, where a relatively high contact drop is required for satisfactory commutation, the heavy, dark film will provide best results, with good brush life and minimum commutator wear. If the machine is so designed that the brushes will chatter, pick copper, and run at high temperatures when a heavy film is formed, the commutator should obviously be operated with a light film. This should produce quiet operation at low commutator temperatures. Local conditions may occur, such as the presence of oxidising chemical fumes, where it may be necessary to operate commutators, regardless of brush life or maintenance costs, with little or no film at all.

Superior operation in most cases may be enjoyed when a relatively heavy film is maintained, provided there are no troublesome machine difficulties to be circumvented. In other words, longer brush life with minimum maintenance expense may be obtained when the film is as dark as is consistent with normal experience.

Regulation of Film

Should the commutator film stabilise at a point which is too thick or too thin and which is undesirable for satisfactory operation, the question arises as to how the desired quality may be produced. If the film should prove to be too dark and heavy, this would indicate, as stated above, that the abrasive action of the brushes was insufficient to remove the material deposited by the negative brushes (on a generator) at a rate necessary to produce the proper film. The simplest method of correcting this condition would be to apply brushes of a more abrasive grade. However, in most cases where electro-graphitic brushes are used on the higher speed commutators, this corrective measure is not practical. When abrasive brushes are introduced on this type of application, the added abrasive also produced a higher brush friction, which may be intolerable as a result of higher commutator temperatures, brush chatter, or other related ill effects. Some other methods used to overcome this difficulty and produce the desired film are as follows :—

(1) Increasing brush tension, when practical. This may also increase friction and commutator temperatures, but in some measure this is compensated by a reduction in contact drop and may prove to be a complete solution to the problem.
(2) Changing to a brush of graphite grade. Abrasives may be added to this type of material with negligible friction increase. On some applications, where mechanical stresses are present, this type of brush is not practical.
(3) Adding one or more arms of graphite (abrasive) cleaner brushes. Where applicable, this is often the simplest and easiest method of solving this problem.
(4) Applying a brush seating " stone." This will remove the excess film until sufficient time has elapsed for the layer to become stabilised.

In a few cases, it may be difficult to build up sufficient film to provide the low friction and contact drop necessary for good brush life and satisfactory com-

mutator operation. This condition may be attributed to one or more of the following causes :—
(1) Too heavy brush tension; (2) the presence of abrasive dust in the surrounding air; (3) copper picking; (4) too abrasive brushes; (5) machine too lightly loaded.

As a rule, film may be increased by decreasing brush tension; however, in some cases, on machines operating at a full load or an overload, this cannot be done without causing selective action. If such is the case, it may be advisable to replace the brushes with a grade that has more film-forming ability. If the source of trouble is due to abrasive dust, the only method of correction is to eliminate the presence of dust at the commutator location. Continued copper picking will always be followed by loss of commutator film. This is caused by the abrasive action of copper embedded in the brush faces. On examination of the brush contacts, copper spots or a coppery sheen will be noticed in most cases. The absence of copper at the contact is not proof that picking is not taking place. Under some conditions, the copper does not remain in the brushes but is eventually pulled away by friction upon the commutator bars. Where this has taken place, the brush faces will show a series of very thin streaks, starting at various points and continuing to the leaving edge. Copper dust particles will also be noted on the brush boxes and rigging. Copper picking may stem from a number of causes, among which may be mentioned the following :—The brushes may be operating off the neutral plane, causing excessive currents in the brush faces; too light tension; high frequency brush chatter; improper spacing of brush arms; overloads; and brush grade too low in contact drop.

If the defect is not due to one of the causes listed above, obviously the machine should be checked electrically and mechanically. Satisfactory film cannot be formed when the machine load is insufficient to provide the negative brushes with enough current to deposit adequate brush material on the commutator. This condition may be corrected by removing brushes until the required current is provided for the remaining brushes.

Incidentally, with regard to brush chatter, it should be noted that this trouble can also occasionally arise from commutator glazing. In this case, despite the apparently ideal appearance of the commutator, which will present a mirror or lacquered finish, the surface has become too smooth, as a result of high friction between the too highly polished or glazed surfaces of both commutator and brushes. The condition of the surfaces in relation to each other is critical. The chatter may be spasmodic, varying with any external condition, such as load or atmospheric changes. The addition of an arm of abrasive cleaning brushes may be a solution, provided they also do not form a highly polished contact surface. Lighter brush tension, where possible, should also be considered.

Effects of Low Humidity

Where machines with peripheral speeds of 3000 fpm or higher are operated, low humidity difficulties may periodically be expected. The condition may be of a mild nature and noted, if at all, only by shorter brush life during the winter months, when the lowest humidity periods occur. Under favourable weather conditions, a number of years may pass before disastrous conditions may be experienced, when, during a period of extremely low humidity, the brushes on some machines may be entirely worn out in a few hours and the brush rigging heaped with dust. The customary film on the commutator will have vanished and be replaced by a raw, brassy colour. The real cause of low humidity trouble is often overlooked, because of the unusually short duration of minimum moisture periods.

Extensive research on the subject of humidity in relation to brush operation reveals the following :—
(1) The critical wear point is a combination of temperature and absolute humidity.
(2) A number of brushes operating together is necessary to reach the critical point (rapid wear could not be produced in the laboratory with two brushes).
(3) The critical moisture point is reached at 2 grains of water per cubic foot, or less, depending upon the brush temperature.
(4) All grades of brushes tested showed rapid wear at low humidities, to a greater or lesser degree.
(5) Rapid wear in low humidities can be produced without current, when heat is supplied externally.

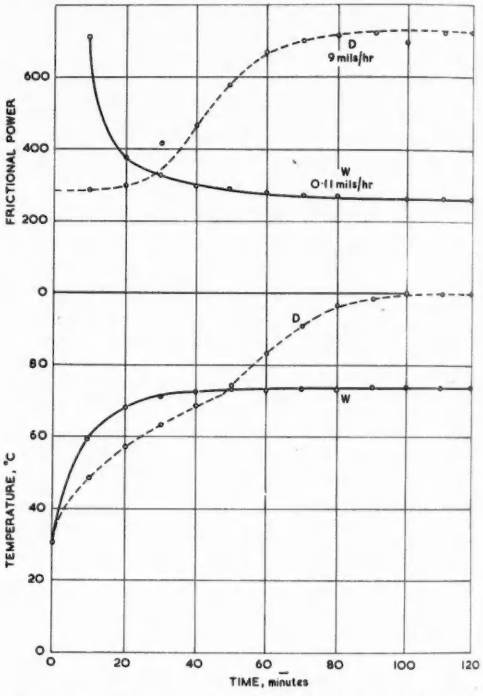

Fig.1. **Curves illustrating typical laboratory wet and dry brush test runs.**
W = wet run, in normal room humidity;
D = dry run, in controlled atmosphere of 0·3 grain per cubic foot of moisture.

Under normal operating conditions, the temperatures are such that a minimum absolute humidity of 1·25 grains per cubic foot has been found to be within safe practical limits. Fig. 1 shows curves illustrating typical laboratory wet and dry brush test runs, the wet run being made in normal room humidity, whilst the dry run is in a controlled atmosphere of 0·3 grain per cubic foot of moisture. After about 40 minutes operation, the test ring lost its film, and both temperature and friction started to increase. The brush wear in normal humidity was 0·11 mils per hour, while the wear in the dry test was at the rate of 9 mils per hour. This test was made with metal graphite brushes on bronze rings.

The practical interpretation of this information seems to indicate that, whilst some brush grades may be less affected than others by the absence of moisture, the only final solution to this problem is to provide some means of controlling low humidity. In many localities it should be economical to add water in the form of spray or steam to the air surrounding machines of large capacity.

Pulsating Firing of Steam Boilers

By F. H. REYNST. (From *Mitteilungen der Vereinigung der Grosskesselbesitzer*, No. 24, June 1953, pp. 419-436, 19 illustrations.)

This article deals with the design and application of systems of pulsating firing, with particular reference to steam boilers. This instalment traces the development of the combustion system and explains its operational characteristics. In our next instalment, the practical application of the pulsating system to steam boilers will be discussed. It is believed that substantial economy in the operation of steam boiler plant is likely to result from this new development.

PART I.

THE conventional steam boiler of to-day may be regarded as a logical development of the first steam boilers, consisting simply of an open fire and an evaporation system. The fact that any fuel, even the poorest, can be used is no doubt an advantage of firing at constant atmospheric pressure. The disadvantages of this system of firing, on the other hand, are the low heat release and small heat transfer obtainable. The heat transfer, at least, can be improved by increasing the draught and the velocity of the gases passing over the heating surfaces. However, if fans, directly or indirectly driven by the steam generated, are used for this purpose, the overall efficiency of the steam plant will be reduced. Repeated attempts, ever since the first steam plants were built, have therefore been made to utilise the flue gases themselves for supplying the additional power required to produce an increase in the draught.

From the thermodynamic point of view, it is desirable that the increase in the entropy in the boiler furnace should be diminished, and this would be made possible by letting the flue gases perform work at the temperature of combustion. If this were possible in practice, a considerable improvement in the overall efficiency might be expected. Up to 15 per cent of the heat of combustion could be converted into mechanical energy in the furnace, if combustion did not take place as a steady constant-pressure process, but intermittently at constant volume, avoiding the unproductive expansion of the gases. The above figure of 15 per cent is not a vague estimate, but is based on operating experience during the last war with the " Schmidt tube," the propulsive unit of the V-1 " buzz-bomb." If, therefore, a Schmidt tube were to be used as a furnace in a boiler, instead of constant-pressure firing, the kinetic energy of the gas jet would amount to almost one half of the turbine capacity. Such a high rate of kinetic energy release is more than is necessary for improving the heat release and the heat transfer in the boiler furnace. In fact, a mere humming of the flame is sufficient to achieve an effect on heat transfer, equivalent to that produced by an induced draught fan. By using this method, which permits a considerable increase in the rate of heat release in the furnace, not only should conventional fans be eliminated, but boiler dimensions should be radically reduced and the energy released in the furnace should be utilised with the smallest possible losses, in order to increase the overall efficiency.

A well-known example of a boiler, in which the flue gases are made to do work, is the Velox boiler. Another example is the combination of steam boiler and gas turbine on the Holtzwarth principle. In this combination, combustion takes place at constant volume in a valve-controlled flash chamber which, however, requires a scavenge fan driven by either a steam or a gas turbine. This arrangement, and plant of similar design, have, however, only a limited field of application as only high-grade fuels can be used, on account of the danger of erosion.

A pulsating furnace, on the other hand, has the advantage that the gas change takes place automatically ; it can, therefore, be operated without a compressor or a power drive and consequently can even be fired with pulverised coal. The Schmidt tube, in addition, has the very considerable advantage of inducing the flue gases to pulsate, and this is of great importance insofar as the movement of particles and the heat transfer processes in a steam boiler are concerned. These pulsations produce a high gas velocity on the heating surfaces, whilst the velocity of the ash particles remains practically unchanged. As a result, the heating surfaces remain unaffected by the erosive action of these particles and, at the same time, heat transfer is greatly improved.

EFFECTS OF PULSATING FLOW ON THE COMBUSTION OF PULVERISED COAL AND ON HEAT TRANSFER.

A pulsating (oscillating) flow is produced when, for instance, pressure variations occur at the inlet of a tube. Fig. 1 shows a section of a tube, with a normal static gas pressure p_0 and a pressure-wave travelling along the tube at the speed of sound c. It can be shown that, if a pressure of amplitude $\Delta p = 0{\cdot}5$ atm is produced by flash combustion, then, for $p_0 = 10{,}000$ kg/m² and a combustion temperature $T = 2000°$ K, gas particle velocity $w = 0{\cdot}0643\ \Delta p = 322$ m/sec. Thus, every gas particle in the tube will be compressed to 0·5 atm and accelerated to 322 m/sec. When the pressure wave has travelled past the gas particle, the latter will again be at a pressure p_0, with zero velocity. It will, however, have changed its position in the tube.

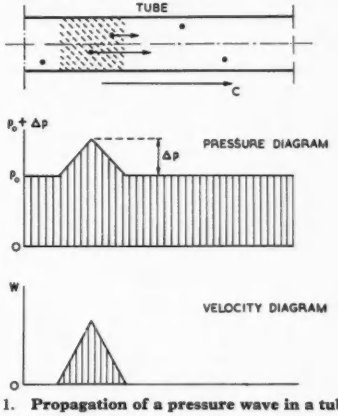

Fig. 1. Propagation of a pressure wave in a tube.

To calculate the acceleration of the gas particles under these conditions, it is assumed, for simplicity of calculation, that $w = 300$ m/sec. and $\Delta p = 0{\cdot}5$ atm. Combustion flashes at the tube inlet are taken to be produced at the rate of n per second. An assumption must also be made regarding the steepness of the wave front, the pressure diagram being taken to be in the form of a zigzag line, with maxima and minima equidistant from the atmospheric line. The gas particles will therefore carry out an oscillatory motion, their maximum velocity w being reached after one quarter cycle counting from zero, so that $t = 1/4\ n$,

Their acceleration is thus $b = w/t = 4\ nw$ and the distance travelled during this quarter cycle is $\frac{1}{2}\ A = \frac{1}{2}\ bt^2$. Consequently, the distance between the two extreme positions is $A = bt^2 = w/4\ n$.

For a pressure amplitude of $\Delta p = \pm\ 0{\cdot}5$ atm, and a maximum velocity of the gas particles $w = 300$ m/sec in

either direction, the acceleration, for a flash combustion frequency of 100 per sec is $b = 4 \times 100 \times 300 = 120{,}000$ m/sec^2 = 12,000 g. The distance between the extreme positions A = 0.75 metres.

This shows that, in the case of a strong pressure wave, the amplitudes of the movement of the gas particles are considerable and that pressure waves must not be regarded merely as vibrating particles. If, at the same pressure amplitude, the frequency is increased from 100 to 1000 per sec, the acceleration of the gas particles will be increased 10 times, whereas the amplitude of their oscillations will be decreased 10 times.

Now, consider the behaviour of solid particles, for instance pulverised coal, suspended in a gas, through which are travelling strong pressure waves. It can be assumed that the solid particles, with their greater specific weight, will remain almost static, owing to the high acceleration and the rapid change of direction of the gas particles. Thus, the relative velocity between the solid particles and the wall of the tube will be practically zero, while the relative velocity between the solid particles and the gas particles will approximate the velocity w of the gas particles themselves.

During combustion, an envelope is formed around the suspended coal particles, consisting of the products of combustion; these reduce the oxygen concentration around the particles and consequently the speed of the reaction. This speed, however, will be increased if the particles move relative to the gas in which they are suspended, since this motion tends to peel off the envelope.

In the case of the cyclone furnace, the relative velocity of the coal particles in suspension is 10 to 20 m/sec, and the resulting combustion time is approximately 0·1 sec. A considerably shorter time may be expected if the relative velocity is 300 m/sec, as in the case of a strong pressure wave. By reducing the combustion time, the rate of heat release is increased. In the case of a cyclone furnace, this is approximately 5×10^6 kcal/m^3-hr, hitherto considered to be the highest attainable. However, the rate of heat release in the Schmidt tube, with pulverised coal firing, reaches no less that 10 times this value. An equally high rate of heat release has been achieved in the pulsating pulverised coal burner of the Soundrive Engine Company, of Los Angeles.

Although the reduced dimensions of the cyclone burner or the Schmidt tube are by no means the decisive factors as regards the size of the whole boiler, as ash cooling must be provided after the combustion chamber, the pressure wave can nevertheless be considered a very effective means of accelerating the surface reaction of pulverised coal.

The size of a boiler is, in the first place, determined by the heat transfer and this, in turn, is improved by the pressure wave in the following way: If a burning mixture of pulverised coal and air flows through a cooled tube at a speed of, say, 10 m/sec, and if a pressure wave, with a maximum gas speed of 300 m/sec is superimposed, the gas particles will carry out a migratory movement at a speed of 10 ± 300 m/sec, whilst the coal or ash particles will travel at a constant speed equal to the basic flow, i.e., 10 m/sec. Erosion need not, therefore, be expected, as the solid particles will not rub against the tube wall at very high speeds. However, owing to the high velocity of the gas particles relative to the tube wall, the heat transfer, as in the case of the Velox boiler, will be very good. The rapid change of direction of the gas flow will further improve the heat transfer, which is largely determined by the thickness of the boundary layer on the wall, this layer decreasing with increase in flow velocity. With steady flow, this boundary layer begins at a short distance from the inlet of the tube and covers the remaining length, thus reducing the rate of heat transfer by its insulating property. With pulsating flow, however, the boundary layer is being constantly broken up, with the result that the hot gases are in direct contact with the tube over its entire length. If, therefore, the gases move along the heating surface with an oscillatory motion, instead of unidirectionally, a much smaller velocity will be required to obtain the same heat transfer rate as with the Velox boiler.

By superimposing in a boiler a strong pressure wave on to a slower basic flow, the following advantages accrue in the case of pulverised coal :—

(1) Rapid combustion, short combustion paths, highly concentrated heat release.
(2) High heat transfer, without erosion.

If the pressure waves are not produced by special equipment, such as pistons or membranes, but use is made of pulsating combustion, as in the Schmidt tube, the following additional advantages are obtained :—

(3) Elimination of induced draught fans.
(4) Removal of kinetic energy produced in the furnace, and its diversion for improvement of overall efficiency.

Older Methods of Flash Combustion

The idea of utilising flash combustion in a boiler to improve heat transfer and at the same time to eliminate draught fans, is very old. Older flash firing equipment can be divided into two classes :—(i) Those in which the frequency of the flashes is not in resonance with the natural frequency of any gas column, and (ii) those in which such resonance exists.

Methods based on the first principle never reached a stage of practical application, as the control gear involved was too complicated and only high-grade fuels could be burnt. Moreover, the frequency of the gas replenishment process was too low, owing to the inertia of the control gear. A high pulsation frequency is particularly desirable, to ensure that only a small quantity of fuel reacts per flash and that the gas forces remain within controllable limits. It would be possible to reduce these gas forces at low frequencies by directing the flashes into a larger number of chambers, on the same principle as the multi-cylinder engine. This, however, would again require special mechanical control gear. While it is true that suggestions were made to utilise a gas column for operating the valves, the natural frequency of such a column was not employed and, as a result, the application remained unsuccessful.

The first flash combustion chambers, in which use was made of resonance, were invented in France at the beginning of the century. One of these early furnaces, designed by Karawodine, is shown in Fig. 2. It consists in essence of a strongly bulged vessel and a pipe. The gas column in the vessel and the pipe oscillates as in an

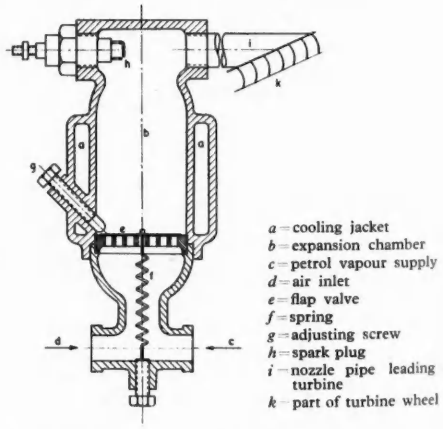
a = cooling jacket
b = expansion chamber
c = petrol vapour supply
d = air inlet
e = flap valve
f = spring
g = adjusting screw
h = spark plug
i = nozzle pipe leading to turbine
k = part of turbine wheel

Fig. 2. **Combustion chamber, designed by Karawodine.**

organ pipe, i.e., in one quarter wave lengths. The vessel is fitted with a non-return valve, opening inwards; the pipe, on the other hand, is permanently open. The combustible mixture flows into the vessel through the valve when the internal pressure is below atmospheric. The vessel thus constitutes a storage supply for the wave motion, and is alternately charged and discharged, a condition which considerably reduces the pressure amplitude and thus the thermal efficiency.

The Schmidt Tube

Early flash firing methods were soon forgotten as, at that time, no practical applications could be found for them. However, in 1937/1938, after investigations on the utilisation of pulsating flash firing for aircraft propulsion, Schmidt re-invented a tube in which the oscillations were maintained by automatic self-ignition.

The Schmidt tube is a cylindrical or slightly conical tube, one end of which is open and the other provided with several non-return flap valves and fuel injection nozzles, as shown schematically in Fig. 3. To start

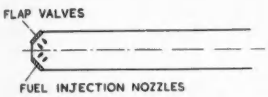

Fig. 3. **Schematic diagram of Schmidt tube.**

operation, the tube is filled with a combustible mixture, which is ignited by a spark plug. The combustion gases escape through the open end of the tube and transmit their impulse in the form of a reaction pressure acting on the valves which, at this stage, are closed. Discharge of the gases reduces the pressure in all parts of the tube to ambient pressure at the time $t = T/2$, where T = duration of one cycle. At this moment, the potential energy of the pulsating gas column is zero, the kinetic energy attains its maximum value, and the compressibility and inertia of the gas cause an additional quantity of gas to flow out of the tube. If the valves are assumed to remain closed, the kinetic energy of the gas will be converted into potential energy at the time $t = 3T/4$, and at this instant all gas particles will be at rest. Thus, the pressure in the tube will be less than ambient pressure, its lowest value being near the closed end and its highest value, practically ambient pressure, at the open end. Consequently, air will be drawn into the tube and, at $t = T$, the velocity of the inflow will be greatest, restoring ambient pressure in the tube. During the period $t = T$ until $t = T/4$, dynamic compression will take place and, at the instant $t = T/4$, the potential energy of the compressed air will be at a maximum.

In actual operation, however, the valves open during the period $t = T/2$ to $t = T$, i.e., when the pressure is lower than ambient pressure, thus causing an air "leak." Part of the oscillatory energy is then used up to draw in air through the "leak." For this reason, the pressure amplitude will not reach its negative peak value, nor will it subsequently attain its positive maximum value. This results in a retardation of air intake at the tube inlet during the period $t = 3T/4$ to $t = T/4$, and in an almost complete loss of dynamic compression during the period $t = T$ to $t = T/4$.

The air aspirated through the valves is mixed with fuel. The mixture does not, however, ignite immediately as, owing to the accelerated air intake, it remains laminar. Turbulent mixing of air and fuel with residual hot gases from the preceding combustion does not, therefore, take place. An immediate ignition would destroy the negative pressure necessary for suction, so that insufficient mixture would be aspirated.

When the mixture column enters the tube, it is surrounded by a layer of residual gases, consisting of the boundary layer along the walls of the tube and of a frontal layer. At $t = T$, the valves close, the flow is retarded, and the boundary layer is peeled off the wall. The resulting turbulence causes an influx of ignition nuclei into the main body of the mixture. On account of the short time required for an ignition nucleus to travel from the wall to the axis of the tube, and the almost simultaneous peeling off of all particles of the boundary layer along the whole length of the mixture column, complete ignition of the mixture is extremely rapid. It has been shown photographically that the flame travels from the wall towards the axis and not axially. The flash produces a rapid rise of the pressure amplitude which, in turn, renews the oscillations. As the valves are closed during the flash, the gases expand in the direction of the open end of the tube, thus acquiring kinetic energy.

Reduction of the pressure amplitudes, resulting from the opening of the valves, cannot be avoided and, although the Schmidt tube therefore operates with virtually no dynamic pre-compression, there is still a pressure increase of almost two atmospheres, owing to the rapid combustion. As a result of this pressure increase, the thermal efficiency of the Schmidt tube is very high.

Valveless Combustion Chambers, with both ends open

In combustion tubes of this type, mechanical valves are replaced by so-called aerodynamic valves, which take the form of a changing cross-section of the tube itself, thus producing expansion and contraction of the flow, mainly in one direction. The gas still escapes in both directions but a very much larger proportion is made to escape through one end. The advantage of this device is that mechanical valves, with their inherently short life, are dispensed with; the disadvantage is a reduction in combustion pressure, due to the leaking away of part of the combustion gases, as indicated above, and the consequent need for provision of ducts to remove these gases in such installations as, for instance, boiler houses.

Combustion Chambers with one opening only

The combustion chamber previously described has two openings, one for fuel mixture intake and the other for combustion gas exhaust. However, as combustion does not take place continuously, but intermittently, combustion chambers have been designed with one opening only, this being used alternately as an inlet and and outlet. The opening can remain open permanently, provided that mixture and combustion gases can be kept apart outside the combustion chamber, i.e., outside the area of pressure fluctuations. This is made possible by

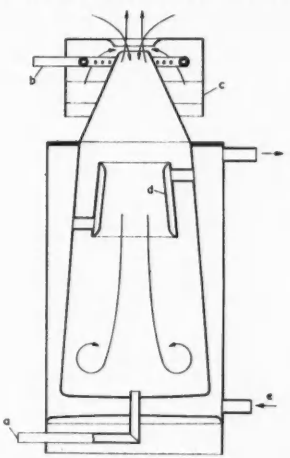

Fig. 4. **Combustion chamber, with only one opening.** *a* = supply pipe for starting-fuel; *b* = fuel supply pipe; *c* = mixing chamber; *d* = internal nozzle; *e* = water supply.

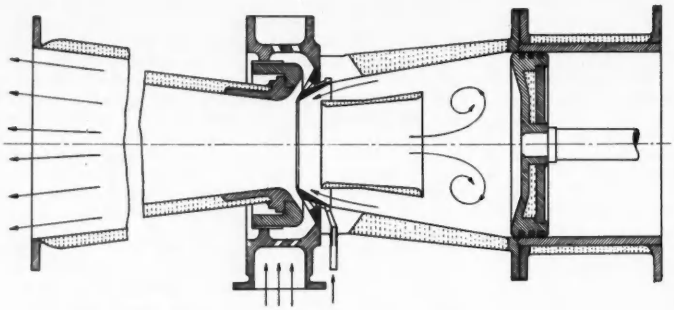

Fig. 5. **Combustion chamber, with one opening and diffuser.**
The piston serves to increase the volume for starting up.

using the aerodynamic principle involved in the formation of a jet during the exhaust phase and the lowering of potential during the intake phase into the chamber.

Fig. 4 shows a cross-section of a combustion chamber designed on these principles. The figure has been drawn to scale, the total length of the chamber being approximately 12 in.

Around the mouth of the combustion chamber is located a mixing chamber *c*, in which the fuel mixture is stored during the exhaust phase and from which it is drawn into the combustion chamber through the annular gap between the two chambers. The cooled internal nozzle *d* serves to guide the suction jet.

For purposes of starting up, a quantity of propane gas is fed continuously into the chamber through a pipe *a* and the mixture of propane and air ignited. An intensive flash is followed by pulsating combustion of low amplitude and frequency (approximately 5 flashes per second). Air and exhaust gases alternately enter and leave through the mouth of the tube. At this stage, the regulating valve of fuel inlet pipe *b* is opened fully, whilst the valve, controlling pipe *a*, is closed. The flashes now increase both in intensity and frequency (20 per sec) without, however, entering into resonance with the natural frequency of the gas column in the chamber. It is, in fact, possible to vary the frequency over a wide range by suitable control of the fuel supply.

The replenishment of the charge can therefore be termed a kind of " thermal breathing " ; in this case, dynamic phenomena play only a negligible part, as the frequency of replenishment is only a small fraction (2 to 3 per cent) of the natural frequency of the gas column in the chamber. Indicator diagrams show peaks of compression with intermediate shallow troughs of depression ; superimposed is a parasitic oscillation of small amplitude and a frequency corresponding to the calculated natural frequency of the gas column in the chamber. By increasing the size of the opening, easier " breathing " of the combustion chamber can be achieved, but this leads to such a decrease in the pressure amplitudes, and hence the jet velocity, that pulsations soon cease entirely.

Further developments of this type of combustion chamber have embodied modifications involving diffusers, to prevent lateral leakage through the annular gap of even small quantities of exhaust gases. These modifications have led to the construction of combustion chambers operating in resonance with the natural frequency of the gas column in the combustion chamber. Operation at resonance frequency has produced a very considerable increase in the pressure amplitude and has stabilised the operating frequency itself, as well as the fuel consumption.

An example of such a modified chamber is shown in Fig. 5, in which all components are drawn to scale. The length of the gas column, measured from the bottom of the chamber to the mouth of the diffuser, is 1 metre (natural frequency $n = 200$ per sec at a speed of sound $c = 800$ m/sec) and the volume of the chamber, without diffuser, is $0{\cdot}01 m^3$. With a fuel consumption of approximately 40 kg/hr, the rate of heat release is therefore 40×10^6 kcal/m^3-hr. The rate of heat transfer is 400,000 kcal/m^2-hr at the bottom of the chamber and 200,000 kcal/m^2-hr in the diffuser. Approximately one third of the heat of combustion is transferred to the cooling water in the chamber and diffuser. The combustion process is stoichiometric, i.e., combustion is complete, and neither smoke nor carbon monoxide is produced, even from the heaviest fuel oil. A diagram of the pressure in the chamber will be approximately sinusoidal, whereas that of the pressure in the diffuser will be greatly distorted. The noise from this particular burner is considerable and may be audible up to a distance of 6 miles.

As fuel is automatically drawn into the combustion chamber, neither an atomiser nor a high-pressure injection pump is required. In fact, the fuel need not even be introduced into the interior of the combustion chamber, but may be applied to the outside wall near its mouth, where it will spread out into a thin layer and will be carried into the chamber automatically through the annular gap during the suction phase. The flow, which at this point has almost the speed of sound, produces a deflection of the fuel from the radial to the axial direction and at the same time ensures its effective atomisation. Consequently, fuel intake, mixing, and ignition take place automatically.

For starting up, petrol is injected and is ignited by a spark plug. During this process, the piston (see Fig. 5) is in the outer position, thus lowering the natural frequency of the gas column in the chamber. At this stage, pulsations are of the order of 10 per sec, subsequently stepped up to about 50 per sec by closing the injection nozzle (not shown in the figure) and providing as fuel a little well-preheated petrol mixed with air outside the chamber. The petrol control valve is now turned on fully and the flame pulsations come into resonance with the natural frequency of the gas column. The piston is then moved to its inner position, raising the frequency to about 200 per sec. The burner may be operated with fuel oil, instead of petrol, but in this case preheating of the oil may be required.

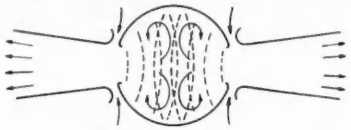

Fig. 6. **Spherical combustion chamber, with opposed openings.**

It is possible to combine two chambers of this type in such a manner that their open ends are opposed and their closed ends omitted, as shown schematically in Fig. 6. This arrangement eliminates gas friction at the base of the chambers and enhances turbulence. If, in addition, the length of the combustion chamber proper is reduced, and the chamber is given a spherical shape (see Fig. 6), the pressure waves are deflected from their original axial into a more radial direction of propagation, thus producing an interaction between pressure waves and vortices, which may result in transverse, as well as longitudinal, wave propagation.

(To be continued).

Efficiency Standards for Heat Engines

By C. Roseti. (From *Tecnica Italiana*, Vol. 8, No. 5, April-May, 1953, pp. 165-170, 2 illustrations.)

The definitions and terms used to denote the various stage efficiencies and overall efficiencies of heat machines do not show a high degree of uniformity. The divergences are not merely of a formal nature but are due to different conceptions of the operating conditions of thermal machines and their auxiliaries. The latter are not always sufficiently taken into account, particularly in heat balances and considerations of power plant economy.

In the following, an endeavour is made to analyse the various efficiencies of heat engines on a uniform basis, stage efficiencies being treated as factors or elements of a chain relating the primary power input to the output power. The analysis has been developed on the following lines :—

(1) A study of various types of machines (reciprocating and rotary, with internal heat generation or external supply of heat).
(2) Retention as far as possible of accepted terms, enlarged or modified where necessary.
(3) Development of the reasoning on a " power " basis, which appears to be the most suitable basis for quantitative evaluations.

I. Power input of the cycle N_0. The power input of the cycle is that power which is taken by the prime mover itself (in the form of a quantity of heat per second) for conversion into mechanical power by means of the cycle considered. In a diesel engine, this is represented by the heat developed by the fuel burnt per unit time. In a gas turbine, it is the amount of heat supplied to it per unit time, taking account of boiler, auxiliaries, and supply system losses.

II. Absolute power N_A. Whatever the cycle adopted, according to the second law of thermodynamics, it is impossible to convert integrally into work the full input power N_0, by passing from a high temperature T_1 to a lower temperature T_2. There is something " absolute " about this impossibility, and the maximum proportion of power which can be converted was indicated by Carnot as depending on the ratio $(T_1 - T_2)/T_1 = \eta_A$, which can be termed the " absolute efficiency " of the conversion.

It should be noted that, besides Carnot's cycle, there is an infinite number of cycles (among them the Ericsson and the Sterling cycles) consisting of two isothermals and two adiabatics, which correspond to maximum conversion efficiency. In no case, however, is the " limiting," " ideal," or " Carnot " ratio exceeded, but it remains as the absolute maximum. Consequently, $N_A = \eta_A N_0$ may be taken as the relation between the absolute power (i.e., the maximum convertible power) and the input power.

III. Theoretical power N_T. The term " theoretical " is not purely abstract. It is not the diametric opposite of " practical ", and serves to indicate a graduation in the possibilities of arriving at real factors by theoretical representation. For instance, there is no possibility, not even " theoretically," of realizing a Carnot cycle or similar cycles. The concept of a theoretical power is justified, however, when considering cycles derived as compromises from the absolute cycles, as, for instance, the Rankine cycle for exothermic prime movers or the Joule-Brayton cycle for engines with gradual combustion. At this stage, the conversion efficienty η_T may be determined by the known relation

$$\eta_T = (Q_1 - Q_2)/Q_1$$

where Q denotes a quantity of heat. With regard to the primary power input N_0,

$$N_T = \eta_T N_0,$$

so that, by introducing an additional stage efficiency η_R as a " relative efficiency " of N_T to N_A,

$$N_T = N_A \eta_R \quad \text{and} \quad \eta_T = \eta_A \eta_R.$$

IV. Indicated power N_I. This term is sufficiently well chosen, both in its meaning and its derivation, to require no change in nomenclature. Strictly speaking, it is derived from the name of a recording apparatus used only for reciprocating engines, but it is quite usual to extend definitions to cases where the object (i.e., the indicated power) is not directly accessible to measurement. Thus, the " indicated efficiency " η_I is the ratio of indicated power to the primary power input, so that

$$N_I = N_O \eta_I$$

and the stage efficiency, relative to the theoretical power N_T, is therefore a factor which may be termed the " specific efficiency " η_S, in accordance with the relations

$$N_I = N_T \eta_S \quad \text{and} \quad \eta_I = \eta_S \eta_R \eta_A.$$

However, some further subdivision is required at this point: In passing from the theoretical to the practical cycle, in the general case of *reciprocating engines*, the specific efficiency includes the following losses :—

(a) Heat losses due to heat leakage through walls.
(b) Heat losses through leakage or condensation of operating medium.
(c) Losses of work corresponding to reductions in the useful area of the theoretical cycle brought into the practical cycle (the indicator diagram).

These losses can be expressed as " local efficiencies "; for instance, (a) can be related to a " wall efficiency " η_W. Losses (b) and (c) already have suitable names, *viz.* " volumetric efficiency " η_{VO} and " dynamic efficiency " η_D respectively, and these can be retained. Therefore, for reciprocating engines,

$$\eta_S = \eta_W \eta_{VO} \eta_D.$$

For *steam turbines*, the characteristic efficiency is the ratio of the enthalpy or total heat converted into kinetic energy to the enthalpy difference initially available. It is, in most cases, closely related to the " dynamic efficiency " η_D of reciprocating machines. It cannot be called " relative efficiency," as suggested by some authors, since it is not in opposition to the absolute efficiency. As for the term " thermodynamic efficiency," this clearly involves an error in conception. Efficiency, as a pure number, is a ratio of two quantities strictly of the same kind, and this is not the case when passing from thermal to kinetic energy. " Enthalpic efficiency " would undoubtedly be more expressive, but the term " dynamic efficiency " will be retained, for the sake of uniformity and because it also applies to reciprocating engines.

Furthermore, in steam turbines the following inherent losses have to be considered :—

(a) Heat losses due to heat leakage through walls.
(b) Heat losses through steam leakage.
(c) Losses in mechanical energy due to friction, or associated with the motion of solid components operating in a steam atmosphere.
(d) Losses in mechanical energy due to cooling effects.

For losses (a) and (b), the terms previously used are fully adequate. Losses (c) and (d) are mainly undesired reconversions of energy into heat. A large porportion of the frictional losses occurs outside the turbine and will be considered separately.

For *gas turbines* of conventional design, the considerations are identical in all respects. In general, the

operating medium (air) follows theoretically the Joule-Brayton cycle. However, as the compressor is not incorporated in the turbine, the turbine cycle, considered independently, is somewhat analogous with the Rankine cycle of steam turbines, when the adiabatic of compression is replaced by an isothermal and the constant-pressure line of the exhaust process is correspondingly extended. The subdivisions are the same as for steam turbines, but the compressor is considered with the driven auxiliaries.

Thus, by means of the "specific efficiency," used as described above, it is possible to treat both rotary and reciprocating prime movers on a uniform basis.

V. Shaft power N_{SH}. This term also requires some clarification. In some cases, the shaft drives auxiliary devices through various transmission systems, whereas in others the auxiliary machinery is entirely operated by separate units. Furthermore, before obtaining shaft power, "mechanical" and "output" losses† must be considered. These terms are extensively used and will be retained in this analysis.

The term "mechanical efficiency" η_M is an overall stage ratio relating indicated power to shaft power, as follows:—

$$N_{SH} = \eta_M N_I.$$

It can be regarded as the product of a number of local efficiencies, *viz.*

$$\eta_M = \eta_F \eta_{VI} \eta_{CO} \eta_G$$

where η_F = "frictional efficiency," η_{VI} = "viscous efficiency," η_{CO} = "cooling efficiency," and η_G = the efficiency of the reduction gears (transmission losses), if these are included in the main shafting. Disregarding η_G, the "output efficiency" η_{OU} of the prime mover, is

$$\eta_{OU} = \eta_F \eta_{VI} \eta_{CO} = N_{OU}/N_I,$$

where N_{OU} is the actual output power of the prime mover.

It is still necessary, however, to specify the position at which this shaft power is measured or calculated. In marine applications, for example, this is essential, since the line shafting may be used to supply power to various sub-assemblies. "Effective power" is not a clear designation, as it does not indicate where the power is effective, for instance, ahead of, or at the position of, the propeller. It is considered that a convenient position for the localisation of this power is at the coupling between the engine shaft and the driven shafting, and this will be termed the "shaft-coupling power" N_{SC}. Thus, the "shaft-coupling efficiency" η_{SC} can be obtained from

$$N_{SC} = \eta_M N_I = \eta_{SC} N_{OU}$$

and

$$\eta_{SC} = \eta_M \eta_S \eta_R \eta_A.$$

Incidentally, it may be noted that the "mean effective pressure" for engines with external heat supply may be termed the "mean shaft-coupling pressure."

VI. Auxiliary power and overall efficiency of the power-plant. If N_H is the total calorific power intake [kgm/sec] of the thermal power plant, C the fuel consumption per hour [kg/hr] and H_L the lower calorific value of the fuel [kcal],

$$N_H = C\, H_L \times 427/3600 \text{ [kgm/sec]}$$

and therefore the "overall efficiency of the entire power plant" $\eta_{O\text{-}E}$ is

$$\eta_{O\text{-}E} = N_{SC}/N_H,$$

which is valid for any type of machine and suitable for any comparisons required.

Fig. 1 shows the application of this analysis to steam turbine plants, and also indicates the manner in which auxiliary power contributions are evaluated.

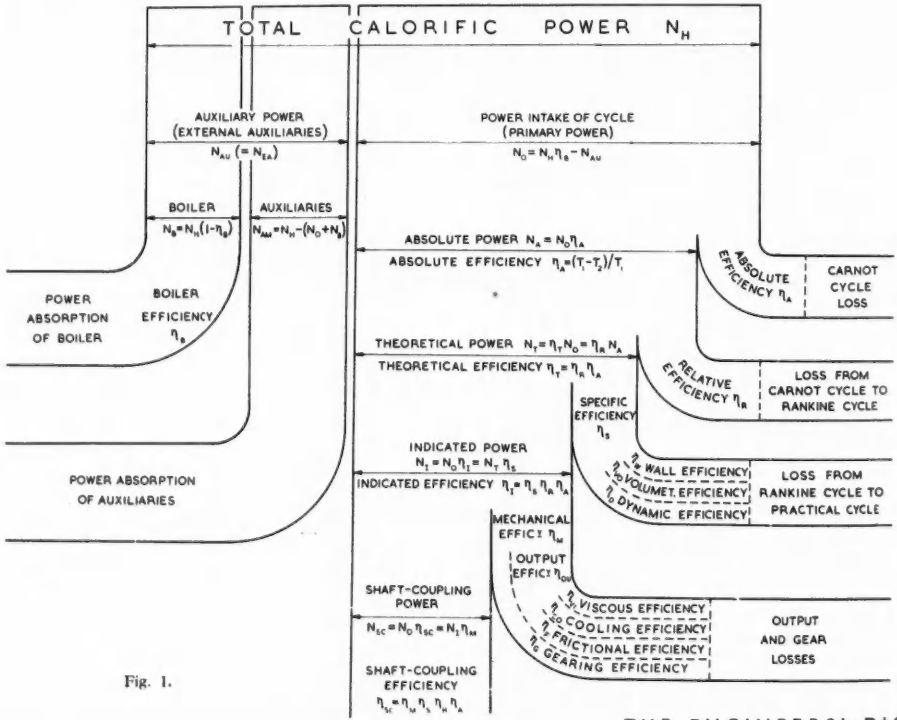
TOTAL CALORIFIC POWER N_H
AUXILIARY POWER (EXTERNAL AUXILIARIES)
N_{AU} (= N_{EA})
POWER INTAKE OF CYCLE (PRIMARY POWER)
$N_O = N_H \eta_B - N_{AU}$
BOILER
$N_B = N_H(1-\eta_B)$
AUXILIARIES
$N_{AM} = N_H - (N_O + N_B)$
ABSOLUTE POWER $N_A = N_O \eta_A$
ABSOLUTE EFFICIENCY $\eta_A = (T_1 - T_2)/T_1$
ABSOLUTE EFFICIENCY η_A
CARNOT CYCLE LOSS
POWER ABSORPTION OF BOILER
BOILER EFFICIENCY η_B
THEORETICAL POWER $N_T = \eta_T N_O = \eta_R N_A$
THEORETICAL EFFICIENCY $\eta_T = \eta_R \eta_A$
RELATIVE EFFICIENCY η_R
LOSS FROM CARNOT CYCLE TO RANKINE CYCLE
SPECIFIC EFFICIENCY η_S
INDICATED POWER $N_I = N_O \eta_I = N_T \eta_S$
INDICATED EFFICIENCY $\eta_I = \eta_S \eta_R \eta_A$
η_W WALL EFFICIENCY
η_V VOLUMET. EFFICIENCY
η_D DYNAMIC EFFICIENCY
LOSS FROM RANKINE CYCLE TO PRACTICAL CYCLE
POWER ABSORPTION OF AUXILIARIES
MECHANICAL EFFICI η_M
OUTPUT EFFICI η_{OU}
SHAFT-COUPLING POWER
$N_{SC} = N_O \eta_{SC} = N_I \eta_M$
η_{VI} VISCOUS EFFICIENCY
η_{CO} COOLING EFFICIENCY
η_F FRICTIONAL EFFICIENCY
η_G GEARING EFFICIENCY
OUTPUT AND GEAR LOSSES
SHAFT-COUPLING EFFICIENCY
$\eta_{SC} = \eta_M \eta_S \eta_R \eta_A$

Fig. 1.

† In the original text, the term "organic" is used instead of "output".—Editor, *E.D.*

Turning with Oscillating Cutting Tools

By S. G. REDKO. (From *Stanki i Instrument*, No. 3, 1953, pp. 24-26, 8 illustrations.)

The author describes tests in which a lathe cutting tool-holder was given an oscillating motion along the axis of the workpiece, and was provided with two cutting tools mounted on a rocking member, so shaped and positioned that the cutting forces automatically ensured a desirable distribution between the relative depths of cut of the two edges. The results of these tests, according to the author, appear to show that such a method of metal cutting may become a competitive alternative to other methods of finish machining.*

THE principle of turning with an oscillating cutting tool is as follows :—Two broad, flat cutting tools, fixed through a rocking member to a spring-loaded sliding tool holder mounted on the tool support of a lathe, are pressed against the workpiece. The cutting edges are so positioned in relation to the workpiece that the inverted top face of the upper tool is tangential with the turned surface and the lower tool has an upright top face placed slightly below centre. The workpiece is rotated and the tools are given a rapid reciprocating motion along the axis of the workpiece.

The addition of the axial motion of the tool to its peripheral velocity is equivalent to a change in the cutting angle, and, owing to the direction of the resultant velocity, the resultant cutting angle will be smaller than the actual angle of the tool bit. Thus, the beneficial effect of a smaller cutting angle, without its drawbacks of lower strength, is obtained. To reduce the effective cutting angle, it is necessary to reduce the peripheral speed of the workpiece or to increase the speed of the reciprocating motion of the tool.

The trajectory of a point on the cutting edge along the developed surface of the workpiece is such that, since two cutting edges are simultaneously in operation and the machining allowance is removed in two or three revolutions of the workpiece, the tool marks are superimposed and give the appearance of a scraped surface.

In the complete unit (Fig. 1), the two tools (6) are fixed to a rocking member (5). This arrangement permits the achievement of the desired distribution of work between the two cutting edges. In the event of an uneven machining allowance or an incorrect shape of the blank, such a tool holder achieves the finished shape of the component in gradual steps.

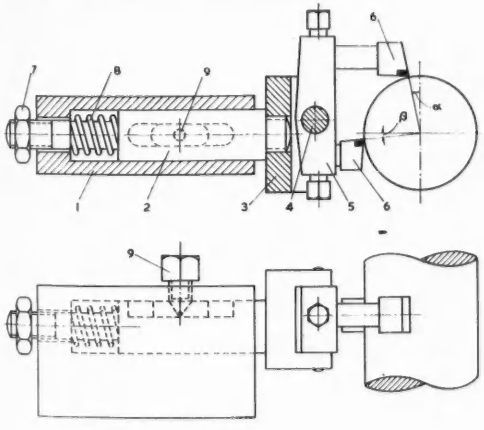

Fig. 1

For instance, when the upper tool first meets a high spot on the circumference of the workpiece, the tangential pressure on the upper tool increases. The tool rocker will tend to rotate about pivot (4), thus forcing the lower cutting edge deeper into the workpiece. The cutting or wedge angle of the lower tool is made larger than that of the upper tool and, in a state of equilibrium, the upper cutting edge will produce a deeper cut than the lower. If the load on both cutting edges increases excessively, the whole tool holder recedes against the spring pressure. When the high spot, in the course of rotation of the workpiece, reaches the lower tool, owing to the difference in the moments of the two cutting edges about the pivot of the tool rocker, the moment of the tangential force of the lower cutting edge will not be as large as the previous maximum of moment arising from the deeper cut of the upper cutting edge. As a result of this relation, the main effect will be a bodily displacement of the entire tool holder against its spring. Thus, any irregularity in the shape of the workpiece will be corrected gradually.

The complete unit is clamped in a square tool-post of a lathe and, as already mentioned, is given a rapid reciprocating motion along the axis of the workpiece. The body (1) of the tool head has a hole in which the shank (2) of the tool holder slides. A fork (3) is screwed on the shank and carries the pin (4), about which the tool rocker (5) is pivoted. This rocker has two holes for clamping two round shanks of the small tipped turning tools (6). The tool holder shank (2), is loaded by a spring (8) secured by a nut (7), and held against rotation by the screw (9), which holds a key sliding in a keyway.

Tests were made with ordinary mild steel and with alloy steel heat-treated to a Rockwell C hardness of 62-64. Workpieces of 60 to 100 mm diameter were turned at cutting speeds between 3 and 25 m/min. The tool was oscillated at a frequency of 1500 cpm along the axis of the workpiece and an amplitude varying between 1·6 and 7 mm. The oscillating motion was imparted to the tool holder by means of an eccentric which moved the whole tool carriage.

The cutting edges were of 10 and 20 mm width. Tool bits of high-speed steel, tungsten carbide, titanium-bearing carbide, and sintered alumina were used. After grinding, the cutting edges were lapped on a cast iron lapping plate.

After various trials, the most appropriate positioning of the two tool cutting edges proved to be that in which the upper edge was displaced from the vertical plane by an angle α of 10-15 deg. in the direction of rotation, the lower edge being displaced downwards by an angle β of 3-8 deg. from the horizontal plane, as shown in Fig. 1.

The pre-load on each cutting edge was 10 kg. A lower pre-load increased the smoothness of the machined surface but lengthened the time of the operation. A rigid attachment of the tools without spring loading did not ensure a smooth surface and led to tool chatter.

Tests with both soft mild steel and with hardened alloy steel gave a high quality machined surface. In fact, the smoothness approached that of a ground surface. The appearance of the surface shows a pattern similar to that obtained with honing, and should have beneficial effects on the properties of the machined surface in operation.

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*The tests described in this article refer to an apparently unorthodox method of metal removal. As tests, they are undoubtedly interesting and, for that reason, it was felt they merited inclusion in our pages.

However, in view of the limited information available, we believe it would be premature to attempt to predict the practical value of this process under actual workshop conditions.—Editor, *E.D.*

The tests appear to show that considerable savings in machining time may be obtained, compared with alternative methods of finish machining.

Tests for time between re-grinds gave various values between 30 minutes and two hours in the turning of soft steels by both high-speed tools and carbide tools. In the turning of heat-treated alloy steel, carbide tips showed a distinct advantage, but even these did not last for more than 15-20 minutes. Sintered alumina tips were unsuccessful for this work.

An increase in the oscillation amplitude of the cutting edge increased the intensity of cutting, as might be expected from the "kinematic" reduction of the cutting or wedge angle. However, a large amplitude (exceeding 4 mm) led to vibration of the lathe, though this did not seem to affect the quality of machining.

Variation in speeds of rotation of the workpiece showed the following behaviour: Synchronising the rotation of the workpiece with the axial reciprocation of the tool led to a return of the cutting edge into the same trace and the machine surface became "knurled." This knurling was also observed when the tool marks of the upper cutting edge coincided with those of the lower. This effect was easily avoided by displacing one of the cutting edges in the direction of rotation of the workpiece.

Tests were also carried out with elliptical blanks. As was to be expected, cutting started at the larger axis of the ellipse and continued to spread until the elliptical blank was turned into a round component.

U.S.A.

Dimensional Stability of Thin Machined Aluminium Alloys

By J. C. WAGNER. (From *Metal Progress*, Vol. 63, No. 6, June, 1953, pp. 92-94, 2 illustrations.)

Extremely close tolerances for flatness and parallelism are often specified in the manufacture of precision instruments. Machining and clamping techniques and stress-relieving treatments are important aids in solving the difficulty of maintaining flatness. This problem seems to be greatly simplified with some of the wrought aluminium alloys.

ACCORDING to a theory recently advanced, certain aluminium alloys absorb more internal stresses from a given amount of cold work than do others. By using an alloy which absorbs only a relatively small amount of stresses from cold work, the manufacture of instrument parts to precision tolerances is considerably simplified.

Because of their availability and common usage, the duralumin alloys 17S, and more recently 24S, have often been specified for precision instrument parts, where low specific gravity is desired. Almost invariably, except when thick sections are involved, some type of stress-relieving of these alloys is necessary when very close tolerances of flatness and parallelism are required. Such treatments of these alloys, originally in the solution-treated and aged condition, are unsatisfactory for several reasons.

The duralumin alloys become susceptible to intergranular corrosion when reheated to about 450° F, which is close to the temperatures used to stress-relieve them. However, even though these alloys are substantially stress-relieved, they seem to have the property of building up internal stresses relatively rapidly when subjected to further machining, and therefore often require additional stress-relieving. Reheating is also objectionable, since physical properties are lowered. If heated high enough to yield a full anneal, they become soft and develop poor machinability. The ideal answer would be an alloy which does not have to be stress-relieved but has physical properties high enough for the required application.

Owing to the excellent corrosion-resistance of alloy 61S-T6 after reheating, stress-relieving experiments were carried out by the Indianapolis Naval Ordnance Plant, to determine the thermal cycle which would yield satisfactory physical properties and would still relieve internal stresses for all practical purposes. The back-reflection X-ray method was used as a guide, since lack of stresses is indicated by the presence of resolved doublets, while the presence of stresses is indicated by diffuse doublets. The chemical composition of the alloys used is given in Table I.

It was found that the doublets representing the 61S-T6 alloy were resolved; those of the 17S-T4 and 24S-T4 alloys were diffuse. Re-solution treatment of the latter alloys always resulted in resolved doublets. Curiously enough, it was found possible to manufacture

TABLE I. COMPOSITION OF ALUMINIUM ALLOYS

Alloy	Nominal Chemical Composition of Alloying Constituents—per cent					
	Cr	Cu	Mg	Mn	Si	Zn
17 S	—	4·0	0·5	0·5	—	—
24 S	—	4·5	1·5	0·6	—	—
53 S	0·25	—	1·3	—	0·7	—
61 S	0·25	0·25	1·0	—	0·6	—
63 S	—	—	0·7	—	0·4	—
75 S	0·3	1·6	2·5	—	—	5·6

many of the 61S-T6 parts to precision tolerances of flatness and parallelism without any stress-relieving treatment, but this was not possible with many of the same parts when the duralumin alloys were used.

One machine shop eliminated the use of the duralumins and changed to 61S-T6. After two years, a survey was made of the results. No stress-relieving was used with many items, but it should be noted that parts were not made in production quantities. Sometimes it was necessary to stress-relieve certain parts of very complicated design, and occasionally use was made of a sheet of 61S-T6 which had behaved poorly in the fabricated part and had to be stress-relieved. Another machine shop decided to stress-relieve the 61S-T6 as a safety measure and reported successful results from a treatment at 450° F. Both shops reported a considerable saving in time and effort in obtaining precision tolerances of flatness and parallelism by eliminating the duralumin alloys and using alloy 61S-T6.

In these experiments, in which tests were made in duplicate, a partially machined gear blank, approximately 13 in. in diameter was used, the requirement being for such a degree of flatness that concentricity of bore and pitch diameter were to be held within 0·0005 in. maximum indicator reading.

With 17S-T4, considerable difficulty was experienced in keeping the gear blank flat. Samples of 61S-T6 were also tried and results were somewhat better. Two weeks later, the gear blanks were again measured for flatness and were found to have gone out of tolerance during this period, even though they had been stored on a surface plate. It was then learned that the 61S-T6 used was slightly warped when received and had been straightened in a press prior to machining. The experiment was repeated using 61S-T6 requiring no

straightening. This time no trouble was encountered. Stress-relieving was not used in the experiments with 61S-T6; the 17S-T4 was heated to 400° F for 1 hr and then air-cooled.

A possible explanation of some of these results is as follows: The re-solution treatment of 17S-T4 removed enough of the stresses so that the doublets on the X-ray films became resolved. The unresolved doublets associated with the as-received material are believed to be due to internal stresses put into the material during a straightening operation at the mill. Alloy 61S-T6 is likewise straightened, but the doublets remain resolved. The difference here is believed to be due to less inherent susceptibility of 61S-T6 to absorb internal stresses.

The duralumin alloys are basically different from 61S, since the former depend on copper aluminide to impart high physical properties after heat treatment. Alloy 61S contains almost no copper and is of the magnesium silicide type. On this basis, 53S and 63S would be expected to behave like 61S in experiments similar to the above. Alloy 75S, although somewhat different from the duralumins, contains considerable copper and would be expected to behave like 17S-T4 and 24S-T4 if the theory is reasonably correct.

A few preliminary experiments were made to check this theory. X-ray diffraction pictures were taken with the following results: 53S-T6 and 63S-T6 yield resolved doublets, while 75S-T6 gives diffuse doublets. The doublets of 63S-T6 are more resolved than those of 53S-T6 and 61S-T6. These results are in agreement with the theory; however, the theory provides no explanation for the superior resolution of the 63S-T6 doublets.

Although it has not been possible at present to perform extensive stability tests on 53S and 63S, it has been established that alloy 75S-T6 is definitely difficult to hold to precision tolerances of flatness and parallelism. The following single experiment was performed, using 53S-T6, 61S-T6, and 24S-T4, which had been resolution treated and aged for 8 hr at 350° F. Samples were made from $\frac{3}{16}$ in. stock, 5 in. long and 2 in. wide. They were then fly-cut at a rapid speed to a thickness of 0·115 in. (± 0·003 in.) and measured for flatness. The 61S and 53S plates were found to be more nearly flat and parallel than the 24S. This is an indication that 53S-T6 is comparable with 61S-T6 in this respect, but much more data must be accumulated before definite conclusions can be drawn. No stability data are available for 63S-T6.

For the reasons already discussed, it is believed that 61S-T6 inherently absorbs fewer stresses under a given amount of cold work than do 75S-T6 and the solution-treated and aged duralumin alloys. It also appears likely that 53S-T6 and 63S-T6 compare favourably with 61S-T6 in this superior ability to remain flat.

RUSSIA

Automatic Arc Welding of Helically Wound Tubes

By I. L. Brinberg, P. G. Rybalko, M. F. Khrobastov, and V. P. Yakushjin. (From *Avtogennoye Delo*, No. 4, April 1953, pp. 1-6, 14 illustrations.)

The authors discuss the advantages of welded tubes in general and of helically wound tubes in particular. Development work leading to the construction of an automatic production line for wound tubes is reported and the separate processes, as used in production, are described in some detail.

Welded tubes have several advantages over seamless tubes. Their superiority consists mainly in a much greater uniformity of wall thickness. In many instances, this allows a saving in metal of up to 15 per cent. Also, large tubes can be made without limitation of wall thickness.

The most productive method of tube welding is that of automatic welding under flux. There are two welding processes which differ in principle from one other. One is the welding of a longitudinal seam, and the other is the welding of a helical seam. Neither process is new, but the first method was developed earlier and a special type of welding machine, evolved by the Ukrainian Institute of Electrical Welding, has been introduced into the welded tube industry. The formed strip, moving at a speed of 100 m/hr, is welded by two successive arcs burning within the limits of a single pool of molten metal over a cushion or backing strip, consisting of a layer of flux on a copper carrier. A simpler, but less productive, method of welding, with the tube stationary, is also in current use.

The welding of helically wound strip has now been developed by the Central Research Institute of Engineering Production. The strip is wound on a cylindrical mandrel, and the butt-joint is continuously welded by an automatic welding head. Uninterrupted operation of the welding machine is ensured by joining the ends of the preceding and the subsequent rolls of strip without stopping the machine, and by electric arc cutting to the desired lengths of finished tube, also without interrupting the welding of the helical seam.

The helically welded tube has certain advantages over the longitudinally welded tube. The helical seam is less heavily stressed than the longitudinal seam; helically welded tubes are therefore stronger than longitudinally welded tubes of the same dimensions. The helical seam increases the stiffness of the tube. Furthermore, tubes with helical seams are more accurate dimensionally and do not require final calibration after welding extending over their whole length.

The production of helically wound tubes is also in some ways superior to that of longitudinally welded tubes. The main advantage is the continuity of the production cycle. Moreover, the size of the helically wound tube is not rigorously related to the dimensions of the strip section. The tube can be of any length, its diameter depending on the width of the strip and the pitch angle of the helix. Within certain limits, by varying the pitch angle of the helix, a strip of given width can be made into tubes of different diameters. The same tube diameter can be produced with strip of different width. Helically wound tubes of relatively large diameter can be obtained from strip of relatively small width.

In the development of helical seam welding, it was necessary to solve several fundamental problems. Insofar as all processes of tube manufacture are continuous, the output is determined by the least productive operation. This operation is the automatic welding of the helical seam. For this reason, the main task was the development of a welding process with the highest possible welding speed, and without violating the essential conditions in tube welding, *viz.*: Fusion throughout the depth of the joint, despite welding from one side only, and full joint strength and formation of

the desired section of the seam. The auxiliary operations of end-to-end joining of the strip and cutting off of the finished tube also needed some development, since mechanical cutting is not practical in a wound tube and oxygen cutting is not sufficiently rapid.

The principal difficulty in achieving a welding speed in excess of 100 m/hr is due to the following conditions : A high welding speed is known to increase the tendency of seams to develop porosity and to lead to poor formation of the desired section. The increase in the power of the arc, necessary for high welding speed, is associated with a lengthening of the welding pool, which can easily lead to an overflow of liquid metal and slag along the cylindrical surface of the tube. Furthermore, the increased power of the arc makes the sliding of a copper cushion underneath the joint more difficult, particularly where there is some misalignment between the edges of the strip.

Preliminary experiments were carried out on flat strips set at a slope, to simulate the lead of the helical seam in the tube. By this means, the favourable influence of the lead on seam formation was discovered.

Using a silicon manganese electrode wire and high manganese flux, it was possible to increase to 300 m/hr the speed of deposition of a bead upon the surface of ring-shaped samples of 600 mm diameter. Welding in full depth was not possible with a sliding copper cushion, because this could not be brought into contact with the fused steel. At that point of the development, therefore, welding was carried out to a depth of 75 to 80 per cent of the wall thickness. The required strength was obtained by means of a raised seam.

The preliminary work was followed by the construction of the first experimental welding machine for the welding of tubes of 100-160 mm diameter and a wall thickness of 2-4 mm. The main development effort was concentrated on the design of the cushion underneath the welding pool and on the electrode arrangement. Neither water-cooling of the copper cushion nor an increase in its pressure against the inner surface of the tube prevented the copper surface from deteriorating by contact with the fused metal. A partial fusion of the seam is not only unacceptable for high-strength tubes but also causes porosity at the root of the welding seam.

Not until the copper cushion was replaced by a flux cushion did full depth welding become possible and porosity of the seam become eliminated. To replenish the flux in the cushion, which is gradually used up owing to the formation of a coat underneath the seam, a new system of flux feeding, with the help of a feed screw, was devised.

Tests have shown that the use of flux only (known in Russia under the trade mark OSZ-45), together with a silicon manganese electrode wire, ensures the absence of pores in the automatic welding of tubes with a wall thickness of 2-3 mm, at a welding speed of 120 m/hr. Comparisons of automatic a.c. and d.c. welding have established the advantages of the d.c. arc, which ensures a greater stability of the process. This is of particular importance in the one-sided welding of thin-walled tubes. On the experimental machine, a welding speed of up to 150 m/hr was achieved with arc currents up to 800 A for a wall thickness of 4 mm and an electrode wire of 3 mm diameter. Under these conditions, a full-depth trapezoidal seam joined the two initially square edges and showed no signs of porosity.

The operational conditions for electric arc cutting of the finished tube were also found from preliminary tests. For wall thicknesses between 3 and 10 mm, and electrode diameters of 4 to 6 mm, the current is in the region of 2,000 A and admits cutting speeds in excess of 200 m/hr. The width of the cut is about 10 mm.

The industrial wound tube welding machine (known in Russia as No. 650) was developed from the original tests and is now in operation in one of the tube plants. It represents an automatically controlled set of machines in the tube production line. This installation carries out all the operations from receiving the strip to cutting the finished tube. The rolls of strip are unwound, the strip is straightened, its end is squared and automatically welded to the end of the preceding roll, the strip is formed into a loop in a pit, the side edges of the strip are cut to constant width and subsequently cleaned and planed to obtain the correct angle for the helical seam, the strip is wound into a helix for the formation of the tube, the helical seam is automatically welded, the continuously fed tube is cut into desired lengths and these are fed to the finishing section for the facing of the ends and testing.

The first welding operation is the butt-welding of strip ends on a butt-welding machine. In this the ends are clamped, a copper cushion is pressed underneath the seam, and the welding is performed by an automatic welding head, which incorporates a flux circulation system and an automatic feed of electrode wire unwound from a spool. The welding arc is supplied with a.c. The raised seam so produced is machined flush with the surface of the strip at another station in the machine.

The automatic end-to-end welding of the strip must be performed very quickly, as, during this interval, the tube winding machine continues to be fed by the reserve length contained in the loop accommodated in the pit. In the latest installation, the duration of the complete cycle of butt-welding of a strip, 1·5 m wide, takes only three minutes, including removal of flux and slag and levelling of the seam.

To prevent the overflow of the welding pool during high speed welding, and to increase the density of the seam, the helical welding is performed in two layers by two welding heads, operating simultaneously, mounted on carriages at a distance equal to the pitch of the helix. The lower layer is welded on a flux cushion replenished by a feed screw. This layer fills the greater part of the joint. The upper layer fills the remaining part of the joint and forms the bulge required for the desired strength of the seam. The welding conditions can be judged from the following example :—A tube of 630 mm diameter and 7 mm wall thickness is welded first with an electrode wire of 4 mm diameter at a current of 1150 A and an arc voltage of 30 V. The speed of welding is 180 m/hr. The arc is supplied with d.c. of reversed polarity. A high manganese type flux and a silicon manganese type electrode wire are used. The upper layer of the seam is formed with an electrode wire of 5 mm, a welding current of 1050 A and an arc voltage of 40 V.

The installation includes a correction mechanism for inaccuracies of the helix angle. This mechanism directs the electrode wire and is controlled by photo-electric cells. The welding current circuit is closed by the tube itself and a sliding brush contact pressed against it by spring pressure.

The machine for electric arc cutting of the finished tube is portable and also operates automatically. In essence, this machine consists of a welding head with a flux reservoir and a spool for the electrode wire, mounted on a carriage moving on rails along the roll-gang at the end of the production line. The welding head is fed with a.c. The cutting process begins when the cutting head carriage is at the extreme position nearest to the helical welding machine. As soon as the arc is struck and has burnt through the wall of the tube, the carriage begins to move at a speed synchronised with the speed of advance of the continuously forming tube. Owing to the rotation of the tube about its axis, the arc burning under flux cuts the wall along a plane section of the tube. After completion of the cutting process, during which the cutting head carriage advances by one pitch of the tube helix, the cutting head returns to its initial position. This completes the cutting cycle.

(*Concluded on page* 315)

Problems Relating to Sparkless Contacts

B C. L. MEYER. (From *Schweizer Archiv*, Vol. 19, No. 5, May 1953, pp. 148-153, 14 illustrations).

TRULY sparkless switching processes occur only rarely in practice, but there is a large number of interesting examples of contacts, where the transfer of contact-material in the sparkless switching region plays a decisive role, as, for instance, in telephone selector-switches, small relays, interruptors, and mechanical rectifiers.

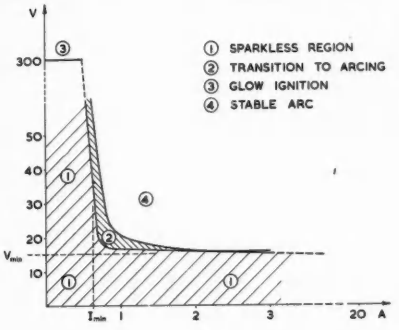

Fig. 1.

Contact arcs will be formed when the voltage across the contact surfaces exceeds a given minimum striking voltage. An investigation into the switching processes for d.c. and ohmic loads establishes the criteria shown in Fig. 1. The limiting values of voltage and current for sparkless switching in ohmic circuits for various materials are given in the table. These values are, of course, only approximate, as many other factors (e.g., humidity of the air, condition of contact surfaces, and type of mechanism) exert an influence. The same qualifications also apply to the validity of the curves in Fig. 2, which relate to the circuit-breaking capacity of various materials.

TABLE OF ARCING LIMITS OF DIFFERENT CONTACT MATERIALS IN OHMIC D.C.[2] CIRCUITS.

Material	Composition	V_{min} (volts)	I_{min}(amperes)
Ag	chemically pure	12	0·4
Au	,,	15	0·3
Pd	,,	15–16	0·8–0·9
Pt	,,	17	0·8–1·0
Cu	,,	12–13	0·4
Ni	,,	14	0·4–0·5
W	,,	15–16	0·8–1·2
Ag/Pd	70/30	12–13	0·4–0·5
Ag/Cd	85/15	11	0·2–0·3
Au/Ni	95/5	15	0·3
Pd/Cu	60/40	14–15	0·7–0·8
Pt/Ir	80/20	18–20	0·8–1·0

In the sparkless region of d.c. switching processes, the well-known phenomenon of material transfer from one pole to the other, first investigated systematically by Holm[1], is the most interesting and important, and forms the subject of the following discussion. Transfer of the contact-material is normally from the anode to the cathode, where it is deposited in the form of fine needles, jagged edges, or domes, leaving a more or less deep crater behind on the anode, as shown schematically in Fig. 3. As a result, the contact surfaces may interlock, the contact-distances may be altered, and after a relatively short period the contacts may become useless.

For measurements of material transfer a highly non-inductive contact circuit is required, and the operating conditions for sparkless operation must be well within the limits given in Fig. 1. In addition, quantitative measurements call for a chatter-free contact, as, with

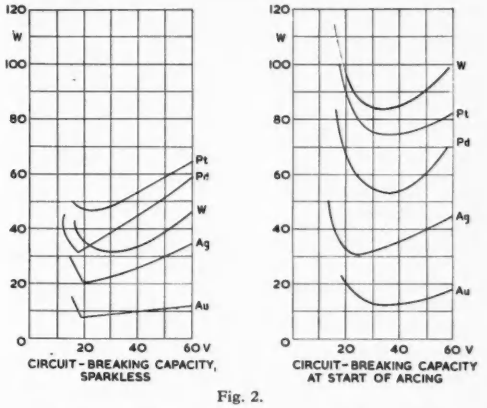

Fig. 2.

even the smallest amount of chatter, the effective number of switchings cannot be controlled. The apparatus used in the tests satisfied these conditions. The movable contact was carried by a leaf spring, which was made to vibrate at 100 cps by means of a small a.c. magnet. The large switching frequency enabled measurements to be made with very small electrical loads and a correspondingly large number of breaks (10^6 to 10^9).

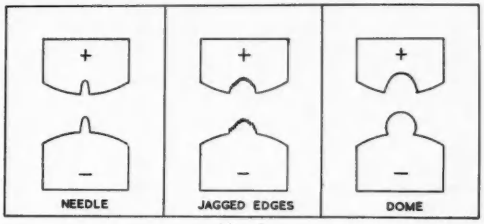

Fig. 3

From numerous experiments, the following empirical relation was derived for the material transfer (see Fig. 4).

$$\Delta A = n k I^{\alpha} \quad (\alpha \simeq 2),$$

where ΔA = loss of material at anode in cm^3
n = number of switchings
k = a constant

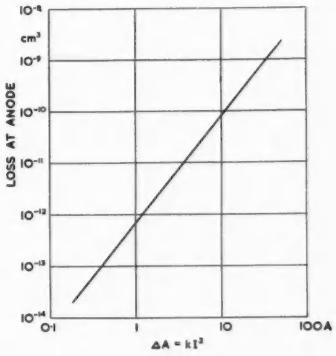

Fig. 4.

F

This relation is approximately valid in the region 0·1-30 A for voltages less than V_{min}, the constant k having different values according to the contact materials employed. The behaviour of contacts for other voltages in the region 5-10 V varies little from the above relation[2].

In investigating the causes of contact material transfer, it is of interest first to establish the maximum temperatures which may occur at the contacts, owing to current flow restriction. According to Kohlrausch & Diesselhorst[3], the relation between the voltage drop in the current constriction and the resultant maximum temperature is

$$\int_{T_0}^{T_{max}} \rho \lambda \, dT = \frac{V^2}{8}$$

where ρ = specific resistivity and λ = heat conductivity. Using the Wiedemann-Franz-Lorenz law, $\rho\lambda = LT$, with $L = 2{\cdot}44 \times 10^{-8}$ volt²/degree²,

$$T_{max}^2 - T_0^2 = \frac{V^2}{4L}$$

and for $T_0 \ll T_{max}$ the approximate relation

$T_{max} \sim 3200$ V (V in Volts) is obtained.

According to this relation, a definite " melting voltage " corresponds to the melting point of a given contact material, e.g., for silver 0·39 V, for palladium 0·57 V, and for platinum 0·64 V. On breaking the contact, this melting voltage is soon reached, and a bridge of molten metal is formed. As the voltage increases further, the temperature of the bridge rises, until the metal evaporates (" vaporisation voltage ") and thus the contact is broken. The size of the bridge can be calculated approximately from theory, and the result agrees in order of magnitude with measurements of material transfer. Fairly extensive experimental results support the above analysis of the contact-breaking process ; some workers have succeeded even in stabilising the molten bridge between the contacts and measuring its temperature[2, 4].

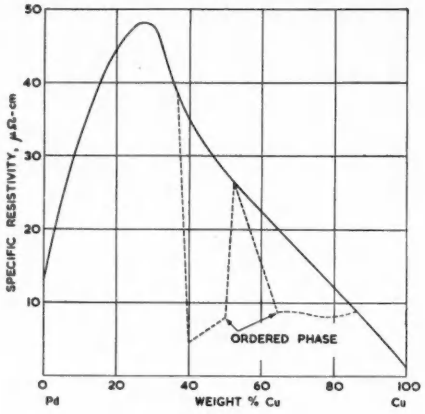

Fig. 5.

It remains to be clarified, however, why the material always flows from the anode to the cathode. A necessary condition for such uni-directional flow is the existence of a temperature gradient between the contacts, the temperature at the anode being the higher. The possible physical causes of the temperature gradient cannot be fully discussed here, but the following may be mentioned :

(1) The Thomson-effect, which consists of the production or absorption of heat by a current flowing along a temperature gradient. This effect, though normally quite small, can be appreciable under the given conditions, but is insufficient to give a full explanation of the material transfer phenomenon, as, for some metals, its sign is not in accordance with that required to account for the direction of the metal transfer[5].

(2) The Peltier-effect, i.e., the production or absorption of heat at the junction of two different metals in a circuit. The molten and the solid state of the contact-material can be considered to constitute two dissimilar metals in contact, and a Peltier effect for such junctions has been shown to exist at least for metals having a low melting point. A Peltier effect can also occur between metals and their oxides ; this can explain the often observed one-sided heating of the anode in oxidised contacts of base metals.

(3) An interesting wave-mechanical treatment of the problem of material transfer has been given by Kohler, but also fails to give a satisfactory explanation of the phenomena involved.

In contacts between different metals, the difference in heat conductivity has an additional important influence on material transfer. According to Lander & Germer[6], the heat energy produced in the molten bridge is some thousands of times greater than the energy needed for the melting and partial vaporisation of the bridge. The excess heat is conducted away through the contacts ; hence, the differential conductivity plays a decisive role in determining the nature of the flow.

The possibilities of experimental confirmation of such theories are meagre, as it is very difficult to vary the relevant parameters independently. If, for example, the electrical conductivity is to be altered, this can usually be achieved only by changing the contact material, and this, in turn, changes many of the other properties of the contact.

In this connection, the behaviour of Pd/Cu alloys is of special interest. For certain ranges of concentration, the alloy enters an ordered phase, with a consequently large increase in conductivity (Fig. 5). Experiments on the material transfer of contacts made of 60/40 Pd/Cu alloy show that there is an appreciable difference in the behaviour of the ordered and the disordered phases. While in the disordered phase, after about a million switchings, a considerable transfer of material takes place, whereas contacts made in the ordered phase show practically no transfer effects after 16 million switchings. If the alloy is brought into the disordered phase, the transfer of material immediately recommences.

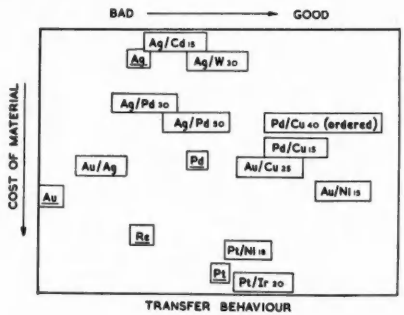

Fig. 6.

The practically important aspect of these investigations is of course the indications given for the suitable choice of contact materials, from the point of view of cost and the avoidance of material flow. Fig. 6 shows various materials arranged according to these properties. The behaviour here considered is restricted to the conditions discussed in the article ; behaviour in other voltage and current ranges, under contact chatter, or

in inductive or capacitive circuits is often quite different from that indicated here; hence the necessity for testing the selected contact materials under actual operating conditions.

Suitable design often helps to minimise undesirable effects, e.g., reduction of chatter often brings the amount of transfer within tolerable limits, or a slight sliding movement of the contact surfaces prevents the formation of specially objectionable needles or points. Finally, the possibility of choosing different materials for anode and cathode in such a way that material transfer is completely absent, should be mentioned[7,8].

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GERMANY

Some Aspects of the Tensile Test

By E. SIEBEL and P. MELCHIOR

(From *Industrie Anzeiger*, Vol. 75, No. 39, May 15, 1953, pp. 4-9, 19 illustrations, and No. 35, May 1953, pp. 3-5, 5 illustrations, respectively).

Professor Siebel's analysis of the plastic deformation of the tensile test bar leads to information about the behaviour of the material under more complicated states of stress. General conditions of fracture can be deduced. The influence of speed of straining rigidity of the testing machine, non-axial loading, and shape and surface of the test specimen are discussed. Lastly, P. Melchior's article shows how the rigidity of the testing machine can be measured and how it influences the autographic record of the machine.

(1) THE TENSILE TEST BAR.

(*a*) *Stresses during plastic deformation.*

The stress-strain diagram of a tensile test bar of ductile material is determined by the resistance the material offers to plastic deformation or to a continuation of this deformation. In the tensile test, this resistance, the so-called flow stress k_f, is represented, according to Tresca's (Guest's) as well as Mieses's criterion, by $\sigma_l - \sigma_q$ where σ_l denotes the true longitudinal tension stress and σ_q the transverse stresses imposed by testing conditions. It is evidently a function of the amount of deformation undergone and, as a measure of this deformation, the reduction in cross-sectional area of the test bar or, in a compression test, the equivalent reduction in height of the test piece, is taken. Therefore,

$$k_f = \sigma_l - \sigma_q = f\left(\frac{\Delta F}{F_o}\right)_{\text{tension}} = f\left(\frac{\Delta h}{h_0}\right)_{\text{compression}} \quad (1)$$

where F_0 and h_0 are the original cross-sectional area and height respectively, before starting the test, and ΔF and Δh the differences between original and actual cross-section or height at any stage of the test. The ratio of actual to original cross-section is

$$\frac{F}{F_0} = \left(\frac{r}{r_0}\right)^2 = \frac{F_o - \Delta F}{F_0} = 1 - \frac{\Delta F}{F_0} \quad .. \quad (2)$$

r and r_0 being the radii of the respective cross-sections in the usual round test bar. The curve $OABC$ of Fig. 1 illustrates this relationship (1) schematically. As long as the test bar remains cylindrical, the transverse or shear stress σ_q remains zero, so that for this first part of the test, $k_f = \sigma_l = P/F$ (Curve OAB). The testing machine indicates the load P acting on the bar or, to another scale, the nominal or conventional stress $\sigma_0 = P/F_0$ which during the first part of the test is (Curve OAB_1)

$$\sigma_0 = \frac{P}{F_0} = \frac{P}{F} \times \frac{F}{F_0} = k_f\,(1 - \Delta F/F_0) \quad .. \quad (3)$$

With increasing deformation $\Delta F/F_o$, k_f increases steadily while the decrease of $(1 - \Delta F/F_0)$ becomes more and more pronounced. Hence σ_o will have a maximum (point B_1 in Fig. 1), the so-called ultimate tensile stress $\sigma_{0\max} = P_{\max}/F_0$, which is the most important feature of the tensile test. Up to this point, the bar extends uniformly over its whole length and remains cylindrical, because any cross-section that may have become more restricted will need a higher load for continued deformation than its less deformed neighbouring cross-section. From point B_1 onwards, any such restricted cross-section will continue to be deformed preferentially under a lesser load and local necking will start.

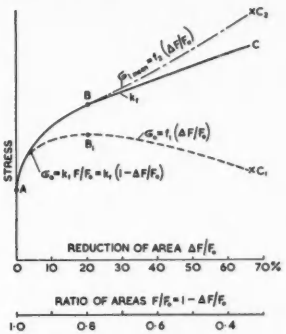

Fig. 1. Stresses during the tensile test.

The longitudinal stress σ_l in the necked portion of the bar is now no longer uniform over the cross-section but increases towards the centre. Moreover, transverse tension stresses also appear, due to the curved outline of the necked portion; their action impedes further deformation, so that the mean longitudinal stress $\sigma_{l\,\text{mean}} = P/F > k_f$ must now exceed that of a similar, but cylindrical, bar (Curve BC_2). The distribution of

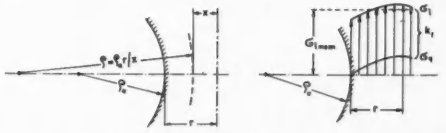

Fig. 2. Stress distribution in necked portion of tensile test bar.

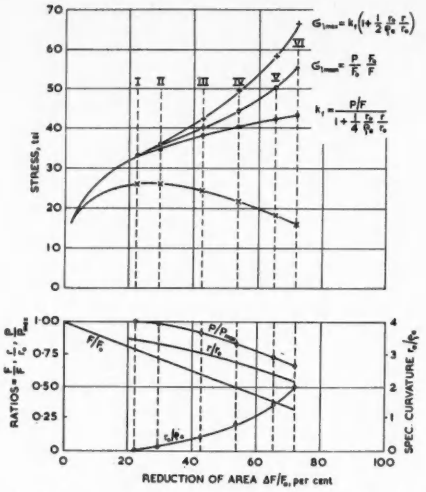

Fig. 3. **Stresses and deformations in necked portion of mild steel tensile test bar.**

the stresses in the reduced cross-section of a round test bar can be determined by a good approximation[1] if it is assumed that the longitudinal stress trajectories in the necked portion follow a curvature of radius ρ varying inversely with their least distance from the centre line, i.e., ρ = prop. $1/x = \rho_a\, r/x$ (see Fig. 2). A parabolic distribution is obtained of the stresses σ_l and σ_q and in particular for purely plastic deformations without volumetric change

$$\sigma_{l\ \mathrm{mean}} = \frac{P}{F} = \frac{P}{F_0}\,\frac{1}{1-\Delta F/F_0} = k_f\left(1+\frac{1}{4}\,\frac{r}{\rho_a}\right)$$

$$= k_f\left[1+\frac{1}{4}\sqrt{1-\Delta F/F_0}\times\frac{r_0}{\rho_a}\right] \quad (4a)$$

whence

$$k_f = \frac{P/F_0}{1-\Delta F/F_0}\times\frac{1}{1+\frac{1}{4}\sqrt{1-\Delta F/F_0}\times\frac{r_0}{\rho_a}} \quad (4b)$$

The maximum stress occurs at the axis of the bar and is

$$\sigma_{l\ \max} = k_f\left(1+\frac{1}{2}\,\frac{r}{\rho_a}\right)$$

$$= \frac{P/F_0}{1-\Delta F/F_0} + \frac{1\times\frac{1}{2}\sqrt{1-\Delta F/F_0}\,\frac{r_0}{\rho_a}}{1+\frac{1}{4}\sqrt{1-\Delta F/F_0}\,\frac{r_0}{\rho_a}} \quad (5)$$

With the nominal stress $P/F_0 = \sigma_0$ indicated by the machine and the specific curvature r_0/ρ_a found experimentally by optical projection, the stresses can thus be calculated (Figs. 3 and 4). For mild steel at the point of fracture, it is found that :

$$\sigma_{l\ \max} = 67\ \mathrm{tsi} = 1{\cdot}22\ \sigma_{l\ \mathrm{mean}} = 1{\cdot}55\ k_f.$$

During the necking of ductile materials, the plastic deformation continues only over a progressively shortening length on either side of the narrowest cross-section ; beyond this length the material remains elastic. The outlines of the necked portion, if projected and traced at various stages of the test, retain the shape once taken, except in the zone still being deformed plastically (see Fig. 4). At the ends of the plastic zone, the curvature of the outlines is discontinuous ; the elastic region is convex and the still plastic region hyperbolically concave. The actual shape of the necked portion is dependent not only on geometrical conditions but also on the ratio $k_f/\sigma_{o\ \max}$, i.e. the strain-hardening characteristics of the material ; the more intensely a material strain-hardens, the slenderer is the necked portion of the tensile test bar.

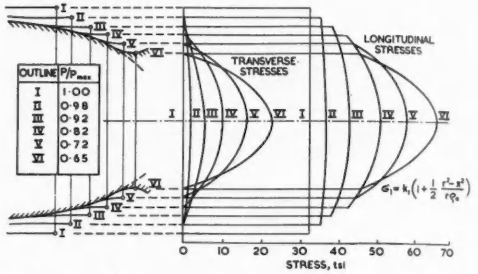

Fig. 4. **Distribution of stresses in necked portion of mild steel tensile test bar.**

The entire mechanism of deformation during tensile tests of ductile materials can thus be calculated, once the flow stress curve of the material is known, and this curve can be derived from the conventional stress-strain diagram. The maximum of the conventional curve, the ultimate tensile stress, occurs when the increase in stress due to strain-hardening balances the decrease due to the diminishing cross-section. It indicates that the resistance of a ductile material against a deformation of about 20 per cent, is determined solely by the flow stress curve, and therefore characterises the behaviour of the material independently of the type of stressing, e.g., simple tension. The elongation and reduction of area at fracture, on the other hand, apply to the tension test only.

(*b*) *Conditions of fracture.*

Even with ductile materials, the tensile fracture is due to cohesive failure, which occurs when the maximum stress $\sigma_{l\ \max}$ at the centre of the narrowest cross-section reaches the cohesive (" brittle ") strength of the material. At the outside of this cross-section, the transverse stresses drop to zero and the longitudinal stresses only slightly exceed the flow stress k_f, so that cohesive fracture at the centre is accompanied by shear failure at the rim ; the well-known characteristic cup-and-cone fracture of the ductile tensile test piece is thus obtained. $\sigma_{l\ \max}$ depends on k_f, and hence on the degree of straining. From the tensile test, the cohesive strength of the material given by $\sigma_{l\ \max}$ at fracture is known for only

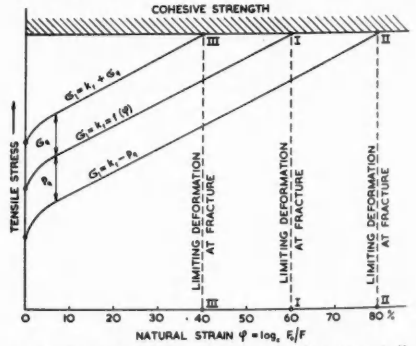

Fig. 5. **Extent of deformation, according to Ludwik.**

one value of prior straining. If, however, it is assumed that the cohesive strength is independent of the degree of straining[2], an estimate can be made, according to Ludwik's representation (Fig. 5), of how much a component made of a given ductile material can be strained before fracture under any particular type of stressing. Curve I is the flow stress curve which in simple tension corresponds to the curve of the maximum longitudinal stress. Fracture occurs when strain hardening raises this stress to the cohesive strength of the material at a limiting degree of straining φ_I. If, in addition, the tensile test piece is exposed to a transverse compression stress p_q, then a smaller longitudinal tension $\sigma_l = k_f - p_q$ will suffice to deform the piece plastically (Curve II) and the greater the transverse compression, the larger will be the limiting deformation φ_{II} at fracture. A transverse tension σ_q, on the other hand, increases the longitudinal tension needed to deform the test piece, and accordingly reduces the limiting deformation (Curve III), since now $\sigma_l = k_f + \sigma_q$. This condition arises during necking of the tensile bar and in tensile tests of grooved or notched bars.

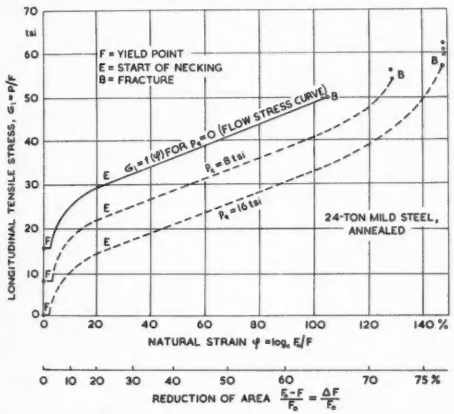
F = YIELD POINT
E = START OF NECKING
B = FRACTURE
LONGITUDINAL TENSILE STRESS, $G_l = P/F$
$G_l = f(\varphi)$ FOR $p_q = 0$ (FLOW STRESS CURVE)
$p_q = 8$ tsi
$p_q = 16$ tsi
24-TON MILD STEEL, ANNEALED
NATURAL STRAIN $\varphi = \log_e E/F$
REDUCTION OF AREA $\frac{E-F}{E_o} = \frac{\Delta F}{F_o}$

Fig. 6. **Tensile tests under transverse pressure.**

Tensile tests under transverse pressure[3] confirm these considerations experimentally (Fig. 6). With increasing pressure, the curves of tr.e longitudinal stress plotted against natural strain are in fact displaced downwards and for each value of strain the difference between the principal stresses, $\sigma_l - (-p_q) = k_f$, is the same for all the curves. The limiting strain at fracture rises appreciably with transverse pressure ; for instance, a pressure of 16 tsi increases the reduction of area from 65 to 77 per cent. However, the cohesive strength does not seem to be constant ; it must be assumed that slip not only strain-hardens the material but also diminishes the cohesive strength of the crystal lattice. In a tensile test bar with a semi-circular circumferential groove of radius ρ leaving a smallest solid cross-section of radius r, conditions resemble those of the necked plain tension bar : The transverse tension stresses $\sigma_{q\,max} = \frac{1}{2} k_f\, r/\rho$, $\sigma_{q\,mean} = \frac{1}{4} k_f\, r/\rho$ in the smallest cross-section increase the longitudinal stress required for plastic deformation and reduce the limiting strain at fracture. Experimental evidence[4] again confirms that there is a drop in cohesive strength with increasing strain.

These considerations show that a component made of a material which has proved ductile in a tensile test may yet fail with little deformation or even brittleness during service. The plastic deformation is reduced whenever the tensile stresses or the maximum shear stress needed for deformation are increased, without a corresponding increase in the cohesive strength of the material. Brittle fracture is the more likely the nearer the actual tensile stresses approach the cohesive strength. Thus, transverse tensile stresses due to notch effect or shrinkage of welds are particularly dangerous. A decrease in the cohesive strength caused by impact loading or low temperatures is equally dangerous and may explain the tendency to brittle fracture of ferritic steels.

(2) TESTING CONDITIONS.

Certain irregularities are unavoidable in practical tensile testing. In general they do not affect the permanent deformation and fracture but have a definite bearing on the yield point and extent of initial yield.

(a) Rate of straining and rigidity of the testing machine.[5]

It is known that the rate of straining influences the magnitude of the upper and lower yield point. On a testing machine with screw drive, a 27-ton 0·09 per cent carbon mild steel showed an upper yield point of 26·5 tsi at an elastic loading rate of 3·6 tsi per sec. and of 24·2 tsi at slow loading rates of 0·426 and 0·235 tsi per sec. The lower yield point was 21·5 tsi for high plastic straining rates, 20·3 tsi for low straining rates (0·02 per cent per sec), and 19 tsi when the material was given time to complete yielding in various stages. The rate and extent of yielding during the drop of load depend on the elasticity of the machine as compared with that of the bar (see also below). Let the bar extend an amount s_3 by yielding as the load drops. If the machine were infinitely rigid, then this extension by yield would be compensated by an equal elastic shortening s_2 of the bar, proportional to the decrease in stress ; no overall extension would be visible and the stress-strain diagram would show a vertical descent. Since the machine is elastic, the drop of load leads to an extension s_1 of the test length, so that with an " elastic ratio " $C = s_1/s_2$, the extent of permanent yielding s_3 is determined by

$$s_3 = s_1 + s_2 = s_2\,(C + 1) \quad .. \qquad (6)$$

If C is very large, i.e., if the machine is very flexible, the yield s_3 will at once lead to work hardening, so that the drop of load is reduced. In fact for $C = \infty$, i.e., direct loading by dead weights, the drop in load disappears altogether. Testing machines are usually very rigid ($C = 1$ to 10), so that the permanent strain s_3/l during the drop of load is small. The above tests at

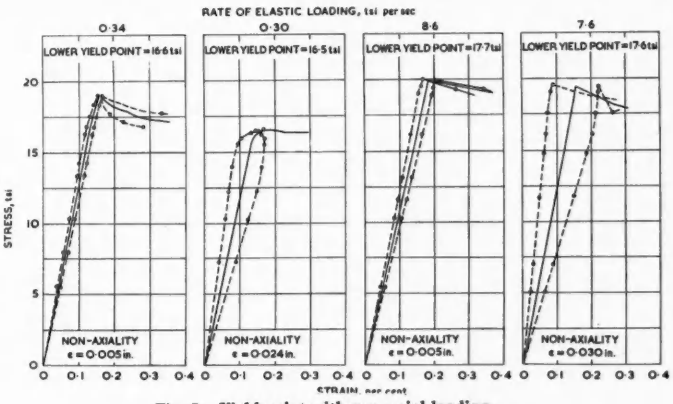
RATE OF ELASTIC LOADING, tsi per sec
0·34
0·30
8·6
7·6
LOWER YIELD POINT = 16·6 tsi
LOWER YIELD POINT = 16·5 tsi
LOWER YIELD POINT = 17·7 tsi
LOWER YIELD POINT = 17·6 tsi
STRESS, tsi
NON-AXIALITY ε = 0·005 in.
NON-AXIALITY ε = 0·024 in.
NON-AXIALITY ε = 0·005 in.
NON-AXIALITY ε = 0·030 in.
STRAIN, per cent

Fig. 7. **Yield point with non-axial loading.**
Full lines, mean strain. Dotted lines, strain of extreme fibres.

different rates of straining were taken with an elastic ratio $C = 6{\cdot}3$. An increase of C to 38 and 63 raised the permanent strain during drop of load by over 1 and 2·8 per cent respectively, the descent of the stress-strain curve thus becoming more gradual. With direct dead-weight loading, a permanent yield strain of 6 per cent was observed to occur in 1 sec without any drop in load.

(*b*) *Non-axial loading.*[5]

The upper yield point is appreciably reduced by non-axial or eccentric loading, the more so the slower the rate of loading (Fig. 7). Yield starts at the extreme fibre bearing the highest stress, and high rates of loading prevent the local yield from extending at once over the whole cross-section.

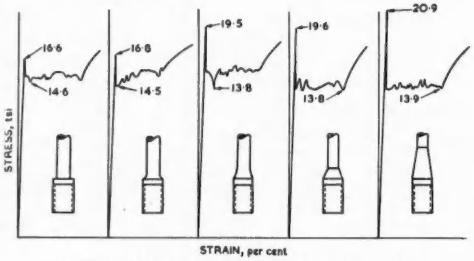

Fig. 8. **Yield point and shape of tensile test bar.**

(*c*) *Surface and shape of test bar.*

The surface smoothness does not noticeably affect the results of the tension test. The shape given to the ends of the test bar is important for the upper yield point.[6] The smoother the transition from head to shank, the less cause there is for a premature start of yielding, which depresses the upper yield point (Fig. 8).

3. Autographic Records and the Rigidity of the Testing Machine.

A rigid testing machine is desirable because it limits unwanted dynamic effects such as sudden yielding. Moreover, the conventional stress-strain diagram, usually obtained in the form of an autographic record, derived from the movement of the cross-head of the machine, will contain the elastic deflections of cross-head, columns, and base, and will thus be distorted, compared with the actual stress-strain diagram of the test bar itself. The elastic deflection of the machine can easily be measured, and the results for three universal testing machines are given in Fig. 9. A short, strong calibrating bar showing no permanent set even at full capacity of the machine is inserted and its elastic elongation between shackles is measured by dial gauge at various loads (Curves A_2, B_2, C_2) ; the deflection of the stationary cross-head connected to the load measuring device is similarly measured against a fixed point on the machine frame (Curves A_1, B_1, C_1). The difference between these two measurements indicates the elasticity of the machine (Curves A, B, C). The non-linearity of the resulting curves and the extent of the deflection at full capacity (0·04 to 0·08 in.) is striking. About 70 per cent of this deflection is accounted for by the linear strain in columns and screws and this is easily calculated. The rest is due less to bending deflections of the cross-heads, i.e., deflections proportional to the load, than to initial deformations, which apparently change in character with increasing loads. Such deformations may be caused by varying pressure between contact faces of screw and nut, columns and cross-heads. Non-uniform contact may also lead to slight initial bending of the columns. As a consequence of these non-linear initial deformations, the machine is from 2·5 to 4 times stiffer at high loads than at the start of the tension test. The unavoidable curving of the start of an autographic record is thus due, not to a faulty autographic mechanism, but to the overall flexibility of the testing machine. In the elastic range of an ordinary tension test on a bar of 8 in. test length, the deflection of the machine may easily be a multiple of the extension of the specimen.

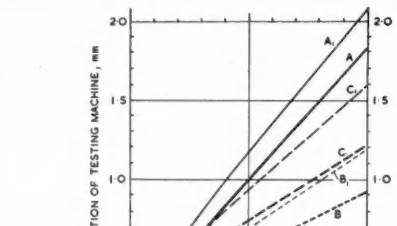

Fig. 9. **Elastic deflection of machine as a function of percentage loading.**

A = Screw-operated beam testing machine, capacity 2 tons.
B = Hydraulic testing machine, capacity 15 tons.
C = Hydraulic testing machine, capacity 10 tons.

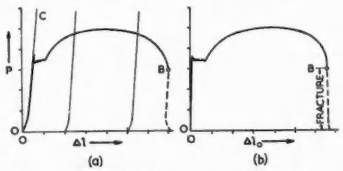

Fig. 10. **Autograph record.**

(a) As registered, including elastic deflection of machine.
(b) Rectified by elimination of deflection of machine, as determined in Fig. 9.

Fig. 10a shows an autographic record OB and superimposed on it the elastic curve OC of the machine repeated at intervals. The actual load-deflection diagram of the test bar, Fig. 10b, is obtained by deduction of the elastic deflection of the machine from the recorded elongation of the bar at each point of the diagram. The resulting elongation Δl_0 refers to the entire length of the test piece and allowance must be made if the test length is smaller. For practical evaluation it will be sufficient if the elastic curve of the machine is regarded as a straight line with an inclination roughly corresponding to that at half the yield stress of the test piece. The initial curve of the record is then neglected, the origin of the diagram displaced slightly to the right, and the autographic record regarded as an actual load-extension diagram in an oblique co-ordinate system. The inclination of the ordinate axis can also be so determined that the angle included by ordinate and elastic portion of the diagram represents the known modulus of elasticity of the tested material.

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New Materials, Processes and Equipment

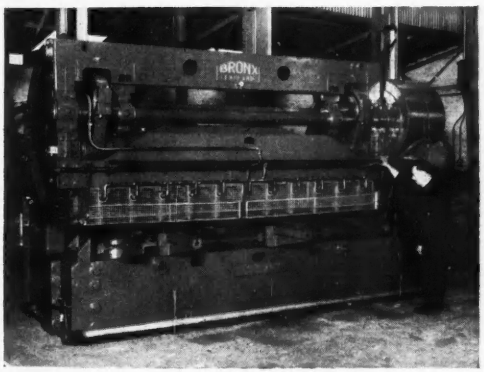
GUILLOTINE SHEARING MACHINE

Production of a new over-drive guillotine shearing machine, for mild steel plate up to 100 in. in width and ½ in. in thickness, is announced by Bronx Engineering Co. Ltd., of Lye, Worcs.

The machine will pass plates of 10 ft in width between the housings, but the blades are made long enough to permit the slitting of long lengths. The rated cutting speed is 20 strokes per minute, the drive being taken from a 20 hp high-slip type of motor directly to a suitable flywheel and thence to a self-contained, self-lubricated work drive unit of ample capacity, which incorporates the clutch mechanism.

The main crankshaft is machined all over from a high-tensile steel forging of highest elongation. The worm-drive unit runs in an oil bath and "one-shot" lubrication is provided to all moving parts of the machine.

The main clutch is of the multi-plate friction type, mounted to the flywheel, and ensures very rapid engagement and release for operation of the machine. The brake is of the cone type and is fitted on the worm shaft and interlocked with the hydraulic system. Front support brackets are included, together with twin, rear fine-adjustment back gauges.



The hold-down units are hydraulically operated, are of fool-proof construction, and are extremely powerful in operation. Special safety interlock equipment is provided to render the machine non-operative for cutting, until the hold-down units and safety front guards are in their working position.

The illustration shows a front view of the new machine.

TUBE FURNACES FOR HEAT TREATMENT OF NEEDLES

To replace the older batch-type furnaces previously used in the heat-treatment of needles, Needle Industries have recently installed the first consignment of an order of twelve vibrator tube furnaces placed with Wild-Barfield Electric Furnaces Ltd., of Watford.

The illustration shows the first battery of these furnaces, which have been specially designed by Messrs. Needle Industries Ltd. and Wild-Barfield Electric Furnaces Ltd. The chamber consists of a solid-drawn heat-resisting tube of 1½ in. diameter by 42 in. long, having an external concentric return tube. The space between the two tubes is filled with insulating material, and cable clamps, which are fixed to the feeding end of each for connection by copper braid to the air-cooled mains transformer. The outer tube is surrounded by insulating powder contained in a cylindrical case, the feed end of which has a flexible plate allowing for the expansion of the tubes, whilst the discharge end is provided with a chute extended down below the surface-level of the oil in the quench tank.

The furnace casing is suspended from above on to short flexible straps attached to vertical pillars, adjustment being allowed for on the front pillar, so that the angle of the tube can be altered and can assist in varying the rate of flow. The thermocouple, situated at the discharge end, has its couple in contact with the inner tube. A syntron vibrator, fitted below the furnace case, provides the energy to cause the needles to flow down the inclined inner tube, and the rate of flow can be varied by controlling the vibrator. Temperature control is achieved by means of an indicating electronic controller mounted in a separate floor-mounting cubicle. This cubicle supports the feed mechanism, the motor and gears for which are enclosed in the base. Needles are fed from the hopper into an adjustable chute so that an even layer is formed on the lower inner surface of the furnace tube.

Each furnace is rated at 6 kW and has a maximum operating temperature of 850°C. The output per furnace is approximately 15 lb per hour, using 4 kW per hour at a temperature of 800-850°C.

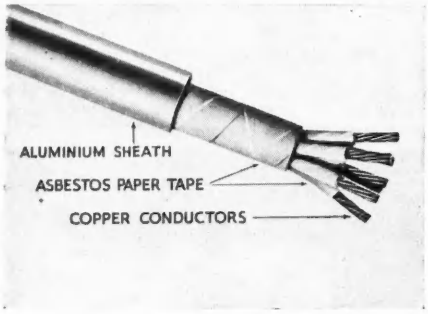
It has been found that only one operator is required for four furnaces, as he needs only to feed the hoppers and to withdraw the hardened needles from the quench tanks as each batch is completed.

FIRE RESISTING AND HEAT RESISTING CABLES

A new patented range of asbestos paper tape insulated cables has been developed by Pirelli-General Cable Works Ltd., of Southampton. These cables are suitable for use in circuits up to 660 volts in situations where fire resistance, non-inflammability, maintenance of electrical properties under elevated temperatures, and non-ageing properties are required.

In the construction of these cables, copper conductors, which may be single or stranded, are lapped with a special quality asbestos paper tape. The cores are laid up, asbestos paper taped, and sheathed with a welded aluminium sheath (Asbestal) or, alternatively, with a welded stainless steel sheath (Asbesteel). The smaller Asbestal cables have a cold-welded aluminium

sheath with a small longitudinal fin, while the larger Asbestal cables have a corrugated argon-arc welded aluminium sheath, which has the advantage of flexibility similar to that of a lead-sheathed cable, combined with sufficient stiffness in relation to weight to enable the distance between supports to be considerably greater than that necessary with lead-sheathed cable.



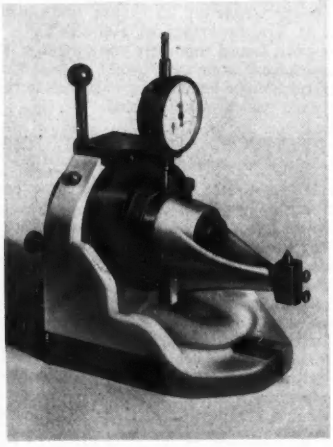
The multicore cables are designed to have a constant insulation thickness between conductors, with a variable thickness between conductors and sheath. The insulant is indestructible and the cable itself will continue to function at temperatures up to the melting point of the sheath. Since the insulant is dry, the cables are non-bleeding, rendering them eminently suitable for vertical runs which may be subject to overload or high temperatures.

The corrosion resistance of Asbestal is similar to that of other types of aluminium-sheathed cable and is in general not very different from that of lead-covered cable. Where increased strength and resistance to mechanical damage are required, Asbesteel cable has certain advantages. The stainless steel sheath has excellent corrosion-resisting properties, which render it particularly suitable for use in chemical and rayon factories. The illustration shows the main constructional features of a 7-core Asbestal cable.

UNIVERSAL RADIUS GENERATOR

Hitherto, the accurate forming of very small semi-circular forms in grinding wheels has been a difficult problem, usually overcome by working in two operations, with the inevitable witness line and the possibility of a misformed profile.

The problem is greatly simplified in the "Habit" Radform, developed by Precision Diamond Products Ltd., of Fulham. The Radform is a completely universal radius generator, providing for all types of radius dressing on surface and other grinders using wheels up to 7 in. in diameter. It generates perfectly formed, exact concave and convex radii from 0·0005 in. to 0·5 in., up to 180 deg. of arc, and its simplicity of operation is such that semi-skilled labour can be safely employed.



Constructional features include anti-friction, wear-resisting correction mechanism; sealing against dust; built-in dial gauge setting; positive, graduated arc limitation; and instant conversion from full to corrected diamond swing.

The Radform illustrated is supplied, complete with dial gauge, in a teak case.

SHOULDER-BRACED FACE GUARD

Amongst operators of high-speed grinders, drills, and similar tools that tend to project particles upwards at high velocity, there has long been a demand for a device to guard the face more effectively than conventional goggles or headband-suspended face shields.

For this purpose, the Protective Industrial Clothing Division of the R.F.D. Co. Ltd., of Godalming, have now produced the R.F.D. Shoulder-Braced Face-Guard, which represents a completely new departure in facial protection, the shield being firmly supported by comfortable felt-lined shoulder braces. A lightweight chemical-proof or flame-proof fabric bib is attached to the lower edge of the shield to protect the neck and chest. The full-vision face shield, which is supplied clear or tinted, is trimmed with aluminium and completely protects both front and sides of the head. The operator has both hands completely free, and the whole equipment can be adjusted or released in a moment.

COMBINED PLAN PRINTER AND DEVELOPER

A new machine giving a medium-fast output of fine quality dyelines, which are printed and fully developed on the one machine, has been developed by E. N. Mason & Sons Ltd., of Colchester.

This machine, known as the LEDA Combined Plan Printer and Developer, has been designed for easy and effortless processing of dyelines, and is intended for use in medium-to-large plan printing departments of engineering and constructional organisations.

Cut sheets or continuous rolls of sensitised material can be used equally well and the operator does not need to stoop, bend or stretch during any part of the printing and developing operation.

The LEDA produces first-class dyelines, fully developed, at combined printing and developing speeds of up to 12 fpm with only one operator. Prints are delivered completely developed, and are odourless and free from stain.

CLASSIFIED ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns, are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

ELECTRIC TRANSMISSION AND DISTRIBUTION

The Treatment of the Load in Electric Power-System Stability Studies.

By S. LAVEMARK. (From *Acta Polytechnica, Sweden*, Electrical Engineering Series, Vol. 4, No. 9, 1952, 53 pages, 25 illustrations.)

THIS paper presents the results of an investigation into the treatment of the load of an electric power-system in stability studies, and covers all forms of load occurring in Sweden. The various loads are divided up and classified under one or other of three groups, *viz.*: Asynchronous load, synchronous load, and heating, lighting, etc. load. The share of the three groups in the total load has been calculated, and a calculation has also been made relating to the distribution of units within the groups according to size. The behaviour of each group during a voltage drop is likewise calculated and presented graphically as a ratio of the load admittance to the prevailing voltage. The load admittance of the respective groups have then been combined to obtain the resulting admittance for the total load.

Since the representation of the network must be simplified as far as possible, for the purpose of stability studies, lines operating at relatively low voltages and the loads connected to them cannot be shown directly, but the load and the lines in series with it may suitably be treated as a single unit. This course has been adopted in the present report, and the ultimate result is presented as the admittance of the load and the series-connected lines as a function of the prevailing voltage. Finally, the components of the resulting admittance have been replaced, with satisfactory accuracy, by very simple expressions.

ELECTRONICS

Rubber Membrane Models for Tracing Electron Paths in Space Charge Fields.

By G. A. ALMA, G. DIEMER and H. GROENDIJK. (From *Philips Technical Review, Holland*, Vol. 14, No. 11, May, 1953, pp. 336-344, 15 illustrations.)

THE motion of electrons in two-dimensional electric fields can be imitated by rolling steel balls over a surface which is a " model " of the potential field. Such a model can take the form of a uniformly-stretched rubber sheet supported in an appropriate manner. It has been found that the effect of an electrostatic space charge can be reproduced by applying suitably distributed pressure from beneath the rubber sheet. Since the space charge is caused by the very electrons whose motion it is intended to determine, it is necessary to employ a process of successive approximation.

A description of the apparatus by means of which the pressure is applied is followed by details of four experiments. The first three of these serve as a check on the method and apparatus used, and hence relate to problems, the solutions of which have been obtained by other methods.

The fourth experiment concerns the motion of electrons in a micro-wave valve. Two simple mathematical examples (plane diode, tetrode) demonstrating the speed of convergence of the results obtained by successive approximation are given in an appendix.

FLOW MECHANICS

The Effect of Roughness on Transition from Laminar to Turbulent Flow.

By H. L. DRYDEN. (From *Journal of the Aeronautical Sciences, U.S.A.*, Vol. 20, No. 7, 1953, pp. 477-482, 9 illustrations.)

A REVIEW is presented of the published data on the effect of roughness, especially single roughness elements, on transition from laminar to turbulent flow, in which an attempt is made to re-analyse and correlate available information. The re-analysis shows that the transition Reynolds number of a flat plate with zero pressure gradient is a function of the ratio of the height of the roughness element to the displacement thickness of the boundary layer at the element, this functional relation being a better representation of the data than a constant critical Reynolds number of the roughness element.

Other data show that the effects of roughness are similar in streams of different initial turbulence, and that a plot of the ratio of transition Reynolds number of the rough plate to that for the smooth plate, against the ratio of the height of the roughness element to displacement thickness of the boundary layer at the element, gives good correlation of all the data for a given shape of roughness element, when transition occurs downstream from the roughness element. At a certain value of the height-thickness ratio, dependent on stream speed, location of the roughness element, and air-stream turbulence, the transition position reaches the element and remains there as the height or the stream speed is further increased.

The paper also discusses available data on the effect of distributed roughness on transition on a flat plate, as well as some of the published data on roughness effects on transition aerofoils.

FOUNDRY PRACTICE

" Dynamic " Method of Casting.

By H. MASTALERZ. (From *Przeglad Odlewnictwa, Poland*, No. 7-8, 1952, pp. 233-239, 3 illustrations).

BY " dynamic " casting is meant vibration of the full mould during solidification of the metal. Laboratory experiments are described in which identical steel castings in the form of prisms were made by normal and " dynamic " methods. For " dynamic " castings, the moulds filled with metal were placed on a vibrator with a frequency of 1440 vibrations per minute. The chemical composition, tensile strength, impact strength, hardness and microstructure of the castings were compared. Untreated and normalised (30 min at 900° C) samples were tested. Average results from 8 samples for all mechanical properties of " dynamic " castings were found to be higher than for normal castings. In particular, the spread of results for " dynamic " castings was smaller, but maximum values for both kinds of samples were similar. " Dynamic " castings were found to be sound, without blow holes. No difference in the microstructure of " dynamic " and normal castings was found. On the basis of these results, experimental castings of railway wheels and other parts with large differences in wall thickness were made. In order to obtain sound castings by the " dynamic " method, changes in the gating system were found to be necessary

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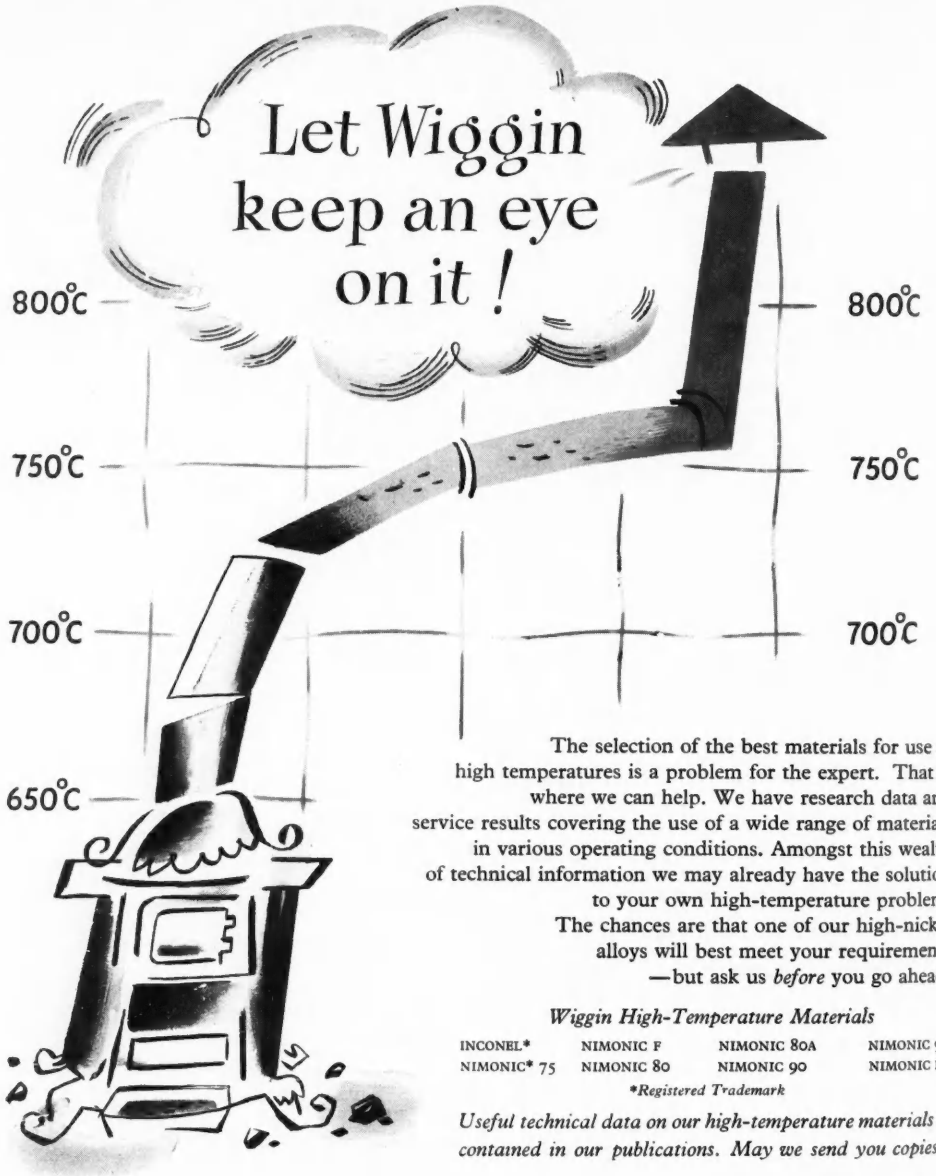

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in some cases. There is no displacement of cores by vibrations, even on multicore castings. As a safety measure, some solidification can be allowed to take place before switching on the vibrator. The influence of vibration on the micro-porosity of castings was tested on steel valves which, when produced normally from electric furnace steel, give up to 30 per cent rejects. Six "dynamically" cast valves did not show any leaks under 600 psi pressure, although they were made from acid open-hearth steel. All these experiments tend to show that the "dynamic" method is successful in producing castings free from micro and macro pores.

METALLURGICAL ENGINEERING

Comparison of Major Types of Oxidation Reactions.

By D. D. CUBICCIOTTI. (From *The Iron Age, U.S.A.*, Vol. 171, No. 21, May 21, 1953, pp. 144-146, 3 illustrations.)

THE oxide formed on the surface of a metal during oxidation determines to a large extent the type of reaction that will occur. The oxide can be protective, tightly adherent, and difficult to penetrate. Non-protective oxides are those which are either volatile at the temperature of the oxidation, or are non-adherent or porous. If the oxide is volatile, or if it is porous or flakes off, it will not protect the metal.

An important relationship exists between the densities of the oxide and metal and the type of oxide formed. If the volume of oxide formed from the oxidation of a given amount of metal is greater than the volume of metal consumed, the oxide may be protective. If the volume of oxide is less than the volume of metal consumed, the oxide cannot be protective.

Oxidations are classed by the form of the curve representing the amount of reaction as a function of time. The most common types are the linear, parabolic, and logarithmic oxidations. The linear law ($w = kt$) is found in the case of non-protective oxides, such as those of sodium, calcium, barium, and similar metals. Since the oxide does not hinder the reaction, the rate is constant and the amount of reaction is linear with time. In the case of a protective oxide, the oxidation can be logarithmic ($w = \log (kt + K)$), or parabolic ($w^2 = kt$). Logarithmic oxidations are rare, but occur with aluminium at room temperature and with silicon at high temperatures. The parabolic oxidation is the most common and, in general, the most studied type. Some metals which oxidise parabolically are iron, copper, manganese, zirconium, titanium, nickel, and beryllium, in order of decreasing oxidation rate.

An interesting, but as yet unexplained, phenomenon observed in several oxidations is a change of oxidation type from parabolic ot linear, with increase in temperature. Uranium oxidises parabolically below 200° C and linearly above. With thorium, the transition is at about 350° C; with calcium, 400° C; with cerium, 130° C; and with aluminium, 500° C.

METALS CORROSION

Determination of R[illegible]stance of Insulating Joints and Pipe-Line Co[illegible]ngs.

By H. F. KOESTER. (From *Corrosion, U.S.A.*, Vol. 9, No. 5, May, 1953, pp. 159-162, 8 illustrations.)

ON coated pipe lines, in which insulating joints or couplings are installed, it is desirable that not only the pipe-coating resistance, but also the insulating joint resistance, be known. On such lines, a determination of the insulating joint resistance cannot be made without a knowledge of the pipe coating resistance on each side of the joint. Similarly, the pipe coating resistance of a section between insulating joints cannot be ascertained without a knowledge of the resistances of the insulating joints at each end of the section.

Measurements of insulating joint resistance made by conventional field methods will always be influenced by current leakage effect through coatings of the adjacent sections. Similarly, a measurement of coating resistance of a pipe section between insulating joints is influenced by the current leakage effect of the adjacent insulating joints.

A method is given by which the true resistance of both insulating joints and pipe coatings can be determined. It combines field resistance measurements and algebraic computations of true resistances. Detailed instructions are given for the positioning of test points and the formulae are explained. A special procedure for use with poorly coated or uncoated pipe lines is described. The method outlined has been adopted in the New York City area and has been found satisfactory.

X-RAY ANALYSIS AND TESTING

X-Ray Analyses of Carbides in Molybdenum and in Chromium Steels.

By K. KUO. (From *Jernkontorets Annaler, Sweden*, Vol. 137, No. 5, 1953, pp. 141-156, 4 illustrations.)

A NEW iron-molybdenum double carbide with unknown structure has been found in steels with 1 to 5 per cent of molybdenum. Its composition is probably between those of $Fe_{21}Mo_2C_6$ and Fe_4Mo_2C, and it is called M_6C_b in this paper. This carbide occurs only after long holding at 700° C and is metastable.

MoC, isomorphous with WC, has been detected in steels having atomic ratio Mo : C between 0·09 and 1·7, after long holding at 700° C. Mo_2C occurs in molybdenum steels at very low molybdenum content (0·4 per cent) and disappears at a much slower rate than does W_2C. It also occurs in the isothermally transformed specimens.

The solubility of iron in MoC is small, and Fe_3C dissolves no more than from 1 to 2 per cent of molybdenum. $M_{23}C_6$ may contain from 2 to 8 per cent of molybdenum, while the molybdenum content of M_6C is between 50 and 60 per cent.

The conclusions drawn from a study of tungsten steels concerning the carbide phases at equilibrium and carbide reactions apply equally well to molybdenum steels with two exceptions, *viz.*: (1) During tempering, the carbides appearing after Fe_3C in steel, with increasing atomic ratio Mo : C, are $M_{23}C_6$, MoC, and Mo_2C; M_6C appears always after Mo_2C. (2) The carbide appearing after M_6C is M_6C_b, not $M_{23}C_6$.

The carbide reaction in molybdenum steels is comparatively slow, requiring at least 5,000 hours to reach this state of equilibrium, possibly because of the high stability of Mo_2C.

In the case of chromium steel, an equilibrium diagram of the system Fe-Cr-C below A_1 containing α-iron, Fe_3C, Cr_7C_3, and $Cr_{23}C_6$ has been given. Cr_3C_2 does not occur in chromium steels.

Chromium can replace iron in Fe_3C to as much as about 18 per cent. The proportion of chromium between Fe_3C and ferrite is 28 : 1. When in equilibrium with ferrite, Cr_7C_3 can dissolve from 30 to 50 per cent of iron, while $Cr_{23}C_6$ dissolves a maximum of 35 per cent of iron.

The carbide reaction $Fe_3C \rightarrow Cr_7C_3$ is found to take place in two stages: firstly, the concentration of chromium in Fe_3C to its maximum solubility; secondly, the transformation from Fe_3C into Cr_7C_3. Contrary to the formation of tungsten- and molybdenum-containing carbides, Cr_7C_3 is formed by the reaction of Fe_3C with the matrix. Fe_3C is also found in high-chromium steels tempered at low temperatures. As the tempering temperature increases, it passes through the state Cr_7C_3 and reaches the final stable state $Cr_{23}C_6$. At high temperatures $Cr_{23}C_6$ is found to be less stable than Cr_7C_3.

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ENGINEERING MARINE & WELDING EXHIBITION

& THE CHEMICAL PLANT EXHIBITION

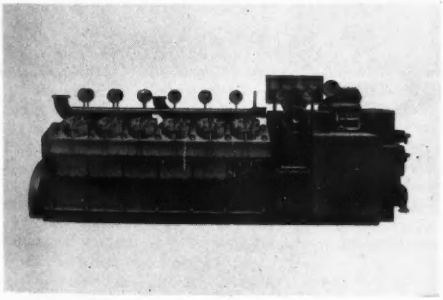
The following is a preview of some of the interesting products to be exhibited at Olympia, London, between September 3 and 17. A further selection of exhibits will be included in our next issue.

Of their comprehensive range of diesel engines, **Crossley Brothers Limited,** of Manchester, will be exhibiting, in addition to a display of working models, five full-scale two-cycle diesel power units from 250 to 1380 bhp, for marine, locomotive, and stationary applications.

The 250 bhp engine is a " packaged power " unit, self-contained with radiator, underbase, and clutch-operated power take-off.

The next exhibit is a 670 bhp marine propulsion engine, representative of a range from 210 and 900 bhp. It is of the two-cycle type, with port-controlled loop scavenge, exhaust pulse pressure charging, and direct-reversing. Fuel consumption is 0·36 lb/bhp-hr.

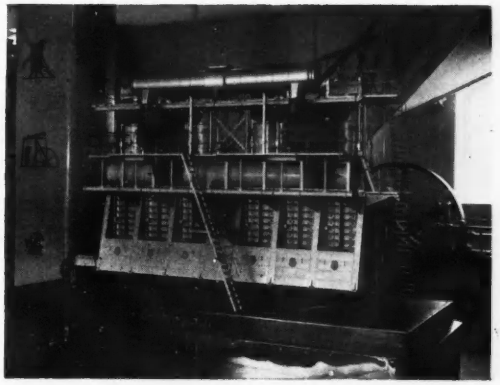
The third engine is the new scavenge-pump 800 bhp general purpose diesel, not previously exhibited anywhere. This unit (illustrated) is a direct-reversing " Vee " type, with 12 cylinders, developing 800 bhp at 1000 rpm. This version of the new power unit is suitable for diesel-mechanical locomotives, and a similar, but non-reversing, engine is available for diesel-electric traction. The unit shown is also closely representative of corresponding marine and stationary types.



The fourth exhibit is the 1100 bhp marine propulsion engine, representative of a range up to 1500 bhp in 8 cylinders at 320 rpm. The design of this engine is similar to that of the 670 bhp unit, mentioned above, except that the scavenge pump used is of the rotary Roots type and is incorporated in the after end of the engine.

The largest unit is the 1380 bhp engine for diesel-electric locomotives. This is an 8-cylinder " Vee " engine and is representative of similar units available up to 16 cylinders and developing 2760 bhp at 650 rpm.

Among other items of interest to marine engineers, **Burmeister & Wain,** of Copenhagen, will exhibit two



working models of marine prime movers, representing the latest development of the B & W 2-stroke, single acting, crosshead, diesel engine with uniflow scavenging, one of the poppet valve type, the other of the opposed piston type, both with exhaust turbo-charging.

The B & W engine is particularly suitable for the application of turbo-charging, as it has uniflow scavenging, a system which requires the least possible amount of scavenging air to expel the combustion products, and leaves the charging air almost free of impurities, ensuring excellent combustion conditions and economical charging.

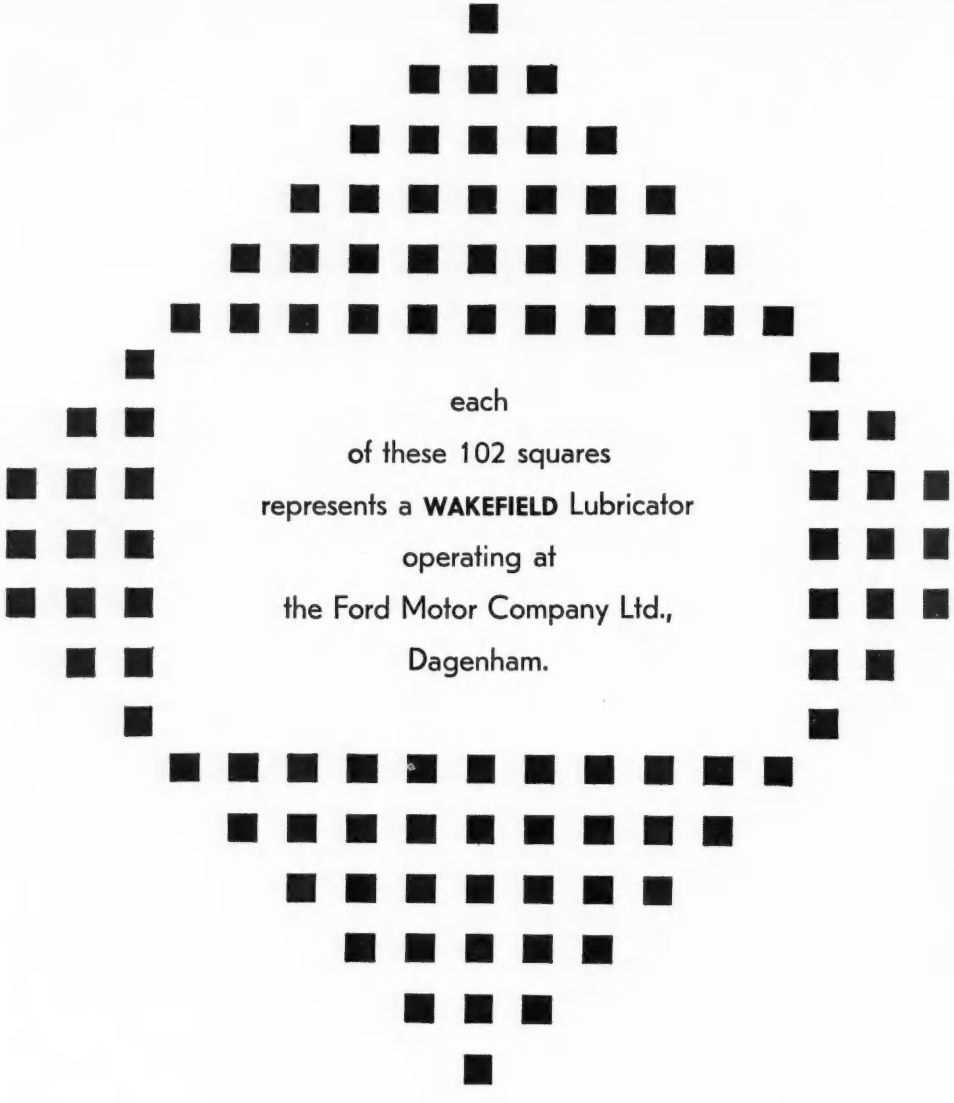
The B & W exhaust turbo-charging system is based upon the impulse principle and is so designed that a maximum of energy is transferred to the turbine wheel, making it possible to operate with relatively large air quantities and pressures, so that low heat flow through the engine and low fuel consumption are obtained.

The charging air is supplied to the cylinders solely by the turbo-chargers, and chain-driven positive displacement blowers have been dispensed with. Starting from cold takes place immediately.

The starting air gives the turbo-chargers a considerable initial speed, which increases instantly with the engine load and revolutions.

A further characteristic feature in the design of the two crosshead engine types represented is the complete separation between cylinders and crankcase, thus protecting the circulating oil in the crankcase from contamination by combustion products, and ensuring that the consumption of lubricating oil is kept to a minimum.

Moreover, the fuel oil injection system is of simple



WAKEFIELD
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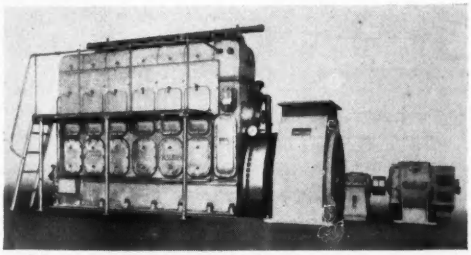
design, easy to adjust, and easily overhauled. These structural advantages, together with those derived from the uniflow scavenging, render these B & W crosshead engines most suitable for operation on heavy boiler oils.

One model shows a 6-cylinder, turbo-charged, 2-stroke, single-acting, crosshead engine with exhaust pistons, the bore being 750 mm and the combined stroke 2000 mm. Engines of this type are built in six different sizes with outputs, when non-turbo-charged, ranging from 500 to 1300 bhp per cylinder at speeds of 100 to 280 rpm. With exhaust turbo-charging, the outputs may be increased by as much as 35 per cent, giving a total output of 17,500 bhp from a 10-cylinder engine.

The other model shows a 6-cylinder turbo-charged, 2-stroke, single-acting, crosshead engine with poppet valves. Engines of this type are produced in four different sizes with outputs, when non-turbo-charged, ranging from 300 to 920 bhp per cylinder, with normal speeds of 100 to 170 rpm. Provided with exhaust turbo-chargers, the power range may be increased to about 1250 bhp per cylinder, giving a total output of approximately 15,000 bhp on one shaft from 12 cylinders.

The largest unit exhibited by **W. H. Allen Sons & Company Limited,** of Bedford, will be the 500 kW diesel generating set illustrated, and comprises a 6-cylinder, 333 rpm engine directly coupled to a 588 kVA, 0·85 power factor alternator, which is also made by Allen. This type of unit is constructed in 3 to 8-cylinder sizes for power outputs from 218 to 750 kW. The complete range of Allen diesel a.c. or d.c.generating sets comprises three different types of unit, covering power outputs from 75 to 750 kW (115 to 1080 bhp). All three types, which are constructed for both marine and industrial requirements, are of vertical design, employing direct injection and arranged for cold starting on compressed air.



The type T47 engine exhibited is of the two-stroke, airless-injection compression-ignition type, operating on the uniflow scavenge principle, and manufactured under licence from Harland and Wolff Ltd. The Allen alternator, which is designed for parallel operation, is of the open, rotating field, salient-pole type, running at the engine speed of 333 rpm, and having a full-load rating of 500 kW, 588 kVA, 0·85 power factor, three-phase, 50 cycles, 415 V, with an overload capacity of 10 per cent for one hour.

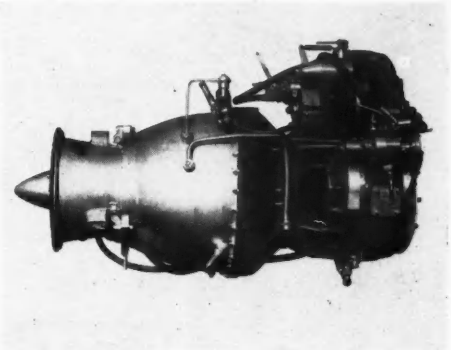
Also exhibited, in addition to a display of epicyclic units and components, is the Allen-Stœckicht double-helical epicyclic gear, designed for a speed reduction from 6000 to 1500 rpm.

The exclusive manufacturing and selling rights of the Turbomeca range of gas turbines throughout the United Kingdom and most of the Commonwealth were acquired in October 1952 from the Société Turbomeca of France by **Blackburn and General Aircraft Limited,** of Brough, East Yorks. For the first time in this country, a range of Blackburn-Turbomeca gas turbines will be exhibited, comprising two shaft turbines (the "Artouste" and the "Turmo" respectively) and a "Palouste" air compressor.

The four Shaft Drive Units range from 158 hp to 394 hp and include the "Turmo" free turbine of 270 hp. The "Oredon" (158 hp) and the "Artouste" I and II (276 and 394 hp respectively) have their two-stage turbines directly coupled to the compressor, the output shaft being driven by a coupling via spur reduction gears to give 6000 or 12,000 rpm.

The "Turmo" is basically an "Artouste" I with a single stage compressor/turbine combination followed by a free turbine, which drives the output shaft through a compound planet reduction gear, giving a maximum output rpm of 3500.

The annular combustion chamber, with rotating disc fuel distributor and burner, is a development which allows the engine to be extremely compact—a great advantage in many applications. These applications include driving industrial or aviation auxiliary equipment, and the free turbine has particular application to the propulsion of marine craft and military tanks.



Typical of the Turbomeca range of gas turbines is the "Palouste" air compressor illustrated. Others in this series are the "Pimedon" and "Arrius" I.

The "Pimedon" and "Palouste" Air Compressors, in which the air is supplied by an oversize main compressor, are units capable of delivering at 15°C 82 lb/min and 139 lb/min respectively at a pressure of 41·2 psig.

The "Arrius" I comprises an "Artouste" I Shaft Turbine directly coupled to an independent centrifugal compressor capable of delivering at 15°C 167 lb/min at a pressure of 31·6 psig.

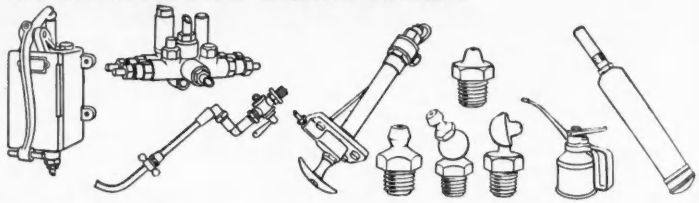
The many applications for these units include supplying compressed air for pumps, air conditioning, coal mining and helicopter tip-propelled rotor blades.

The "Palouste" will not only be exhibited in its self-contained transportable rig, but also its various components will be set out in an "exploded" display.

The mechanical conveyance of dry materials in a closed circuit has the advantages of the simplification of installation equipment during processing stages, and the elimination of the tendency for powder to disperse into the atmosphere of the factory during handling. The DM12 Mono Pump, to be exhibited for the first time by **Mono Pumps Limited,** of London, achieves this object economically.

The intake and output are uniform and therefore steady quantities of powder progress through the pipeline at the same rate of flow. This steady rate of flow is the great advantage offered by the pump. For simple installations, air injection is not necessary but, where the conveyance of powder involves greater distances than those encountered on simple transfer duties, the aid of injected air is enlisted to fluidise the powder and to prevent a build-up of high pressure whilst the powder is progressing towards the discharge point. It must be emphasised that this injected air is not used for

LUBRICATING EQUIPMENT



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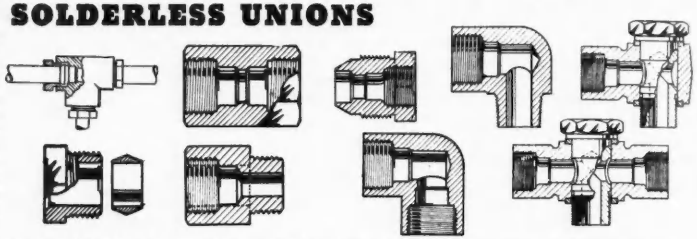

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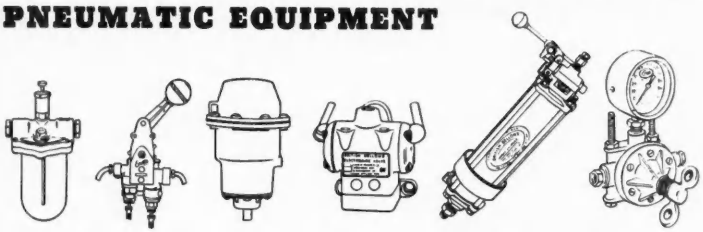

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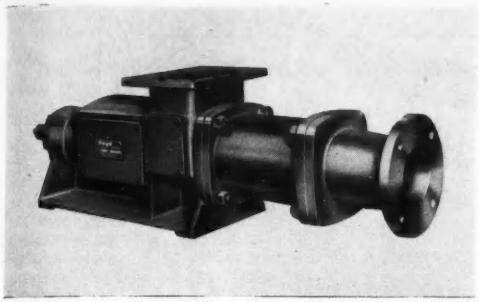
We are exhibiting on STAND 3800, Hall 3 at the European Machine Tool Exhibition, Brussels. September 4th to 13th, 1953.

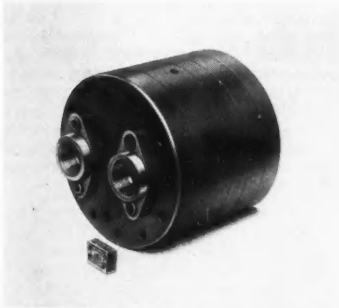


the purpose of blowing the powder through the pipe, but only to relieve friction within the pipeline. The assistance from injected air is kept within very low limits and hence an economy in equipment and in power is achieved, compared with the blowing of powders by compressed air.

In an experimental installation, with a 90 ft circuit of 3 in. diameter piping, including a 25 ft vertical length, the DM12 Mono Pump handled 7 to 8 tons (450/520 cubic feet) per hour of powder weighing 35 lb per cubic foot. Suction was flooded. On the discharge side of the pump, air injected at a pressure approximating 5 psi at 10 cubic feet volume per minute sufficed to keep the powder in afluidised condition.

On exhibition for the first time by **Keelavite Rotary Pumps and Motors Limited,** of Coventry, will be the new 10 cubic inch gear unit illustrated, which will operate as a hydraulic pump or motor in either direction without modification. Several new design features are incorporated, in addition to the patented hydraulic balancing system, which eliminates the need for rubbing plates and prevents radial and axial displacement of the gears. A smooth torque characteristic and extremely quiet running are ensured under all operating conditions.

The maximum continuous working pressure is 2000 psi and overall efficiencies in excess of 85 per cent have been maintained after prolonged periods of heavy duty operation. Working as a pump at 2000 psi, the units will develop 75 hp at 1500 rpm. Peak working speed is 3000 rpm. The unit is only 11·5 in. in diameter by 12 in. in length.

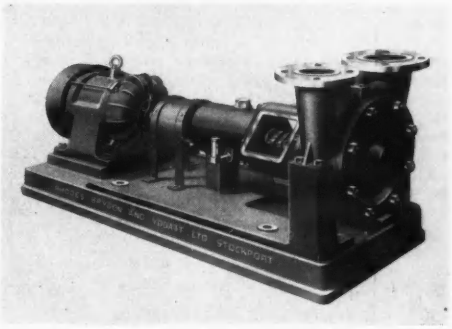


Representative of the smaller range of gear pumps recently developed are units of 1·5, 3, and 4·25 cubic inches respectively. All three units are identical in construction and operation, and can be used as pumps or motors. The two smaller units will operate at a pressure of 1500 psi, and the larger unit at 1000 psi. Maximum speed rating is 3000 rpm.

Among many other exhibits displayed will be hydraulic cylinders available in five bore sizes from 2 in. to 6 in., with strokes up to 130 in.; fixed and variable capacity rotary abutment units for operation as hydraulic pumps or motors, suitable for pressures up to 1500 psi; gear pumps and motors for pressures up to 2000 psi; and a selection of flow and speed control, non-return, relief, bypass, and reducing valves.

The " C.P." range of Mopumps, specially designed to meet the demands of chemical process engineers, will be exhibited by **Rhodes, Brydon & Youatt Ltd.,** of Stockport.

Of the horizontal, single stage, centrifugal type, the " C.P." Mopump is made with 2, 3, 4, or 6 in. inlet bore. Three types are available, suitable for 35, 55 and 90 feet total head (equivalent of water at 60° F) at 1450 rpm, or 150 to 200 ft total head at 2900 rpm. All are built to withstand a maximum static pressure of 100 psi, and are suitable for operating temperatures up to 300° F.



Whilst performance figures are given for water, the pumps are designed to handle liquids of up to 1000 centistokes kinematic viscosity (i.e. approx. 4000 sec Redwood No. 1 or 4700 sec Saybolt Universal), although it will be appreciated that a considerable reduction in performance is inevitable when dealing with high viscosity liquids.

Particular attention has been paid to interchangeability of parts, and the twelve sizes of pump body can be accommodated on only two sizes of bearing assembly and shaft. Contact parts can be supplied in a wide range of alloys, including gunmetal, acid resisting bronze, stainless steel, etc. For operating temperatures above 220° F, a water-cooled stuffing box is employed.

A typical Mopump in this range is illustrated.

Also exhibited is a $\frac{3}{4}$ in. vertical Mopump for the transfer of molten liquids at high temperatures, such as molten caustic soda at 500° C. This pump is arranged to be slung from above the tank, following the falling liquid level, and thus extracting only the top portion of the liquid, leaving scale, slurry, etc. at the bottom. The capacity is 10 gallons per minute at 3 to 4 ft head.

Casing. Circular pump casing in cast iron, with central suction branch at bottom. No gland is employed—an external discharge pipe is fitted.

Impeller. The single inlet impeller is of high silicon iron.

Shaft and Column. The hollow shaft and the column are of stress-relieved mild steel, both being of welded construction. The bottom bearing bush is of cast iron, with a large clearance, and is lubricated by the liquid being handled. An asbestos heat insulating plate is fitted between the top of the column and the flange of the motor.

Motor. A drip-proof squirrel cage motor of $1\frac{1}{2}$ hp is employed.

Since improper handling can be dangerous, detailed instructions are issued by the makers with every pump.

In addition to a wide selection of clutches, power take-offs, filters, etc., a full range of Borg & Beck

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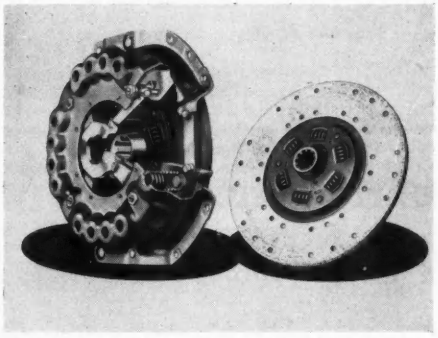
clutches, from 6½ to 16 in. in diameter will be displayed by **Automotive Products Co. Ltd.,** of Leamington Spa.

The " A " type range of single, dry plate, clutches varies from the 6½ in. with a torque capacity of 38 lb-ft, to the 11 in. with a capacity of 185 lb-ft.

The new 12 in. and 13 in. A.S. strap drive types rely for the transmission of the drive from cover to pressure plate on a group of four pairs of tempered steel straps. One end of each pair of straps is riveted to the cover flange, while the other end is bolted to the pressure plate. The straps are arranged in a tangential position so that they can deflect as the clutch is released without disturbing the concentric position of the pressure plate. Thus, accurate balance is maintained throughout the full range of travel of the clutch levers. Friction, rattles and squeak in the actual drive are entirely eliminated, as there is no rubbing contact whatever between the pressure plate and the cover of the clutch. These clutches are supplied for flat faced flywheels. A 12 in. strap drive clutch of this type is illustrated.



The 14 in. and 16 in. heavy duty clutches are provided with needle roller-bearing fulcrums and knife edge contacts in the release lever mechanism, resulting in improved actuation with a lighter pedal effort and longer potential life. The special facing material used on the rigid centre-driven plate gives exceptionally long life. These clutches are very suitable for applications where continual stopping and starting is a necessary feature.

The range of products to be exhibited by **Alfred Wiseman & Co. Ltd.,** of London, includes a series of totally enclosed spur and single helical gear boxes, embodying hardened and profile-ground teeth for driving marine displacement pump drives. Also included is a range of gear type couplings, with specially barrelled geared teeth to allow for misalignment, for both marine and industrial purposes.

Featured in the exhibition will be the Wiseman geared motor unit illustrated. This is a new product, specially designed to accommodate the new British Standard totally enclosed, fan-cooled range of flange-mounted motors, British Standard range size being from B.183D to B.326D, covering ¾ to 25 hp. The Wiseman range consists of ten sizes, embodying both double and triple reduction gears.

In addition, a complete range of standard totally enclosed reduction gear units, of the fan-cooled, single reduction worm and double reduction worm types, will be exhibited, together with resilient gear wheels for use on both diesel electric locomotives and industrial shock load drives.

Among other exhibits, **P. C. & C. K. Chase Ltd.,** of Cobham, Surrey, will be demonstrating on their Stand collapsible containers which are an improvement on those shown at the 1952 Mechanical Handling Exhibition. These exhibits have been developed to assist users who need to conserve space within the factory and environs, and when used in conjunction with road or rail transport.

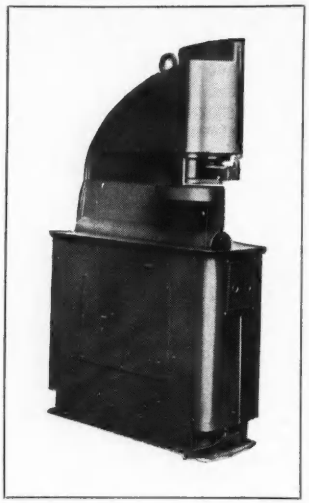
The unit can be used as an open frame stillage or as a box container. In the latter case, the lower panel, the back panel, and the front panel with half drop door, are detachable, and when removed are placed on the platform. The enclosed sheet-metal sides shut inwards and down, and the combination of sheet and angle flanges acts as a lid, locking safely inside the three detachable panels, which may be of sheet steel or wire mesh, as required.

A ratio of more than three to one is claimed in the stacked, collapsed condition, with no loose parts, as indicated in the illustration, which shows both models collapsed, and one added, to demonstrate this three to one ratio.

A range of sizes will be available for handling loads of from 5 cwt to 1 ton.

Soda water was formerly used as a standard grinding coolant and is, in fact, still used in some workshops for certain operations. As a coolant, it is reasonably satisfactory, but it possesses many disadvantages, among which are its ill effects on the hands, and on machines and workpieces.

Some years ago, **Messrs. Edgar Vaughan & Co. Ltd.,** of Birmingham, introduced a soluble grinding coolant, an oil which formed a transparent solution when mixed with water, and this is in wide use for general operations. Now, however, to meet the requirements of superfine grinding of tough hardened steel, cast iron, chilled iron, etc., they have introduced and will be exhibiting a non-oily coolant, known as " Transparent."



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- ★ Weighs only 5 cwt.
- ★ Up to 17 tons pressure on the shear blade.
- ★ Fully automatic operation and foot control.
- ★ Cutting speed up to 34 cuts per minute.
- ★ Grip on Metal to be cut up to 1½ tons.
- ★ Mild steel bar up to 4″ × 1¼″ cut at one stoke.
- ★ Negligible burr on cut metal.

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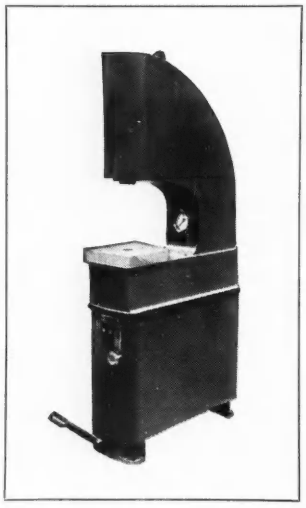
TWO PILOT MACHINES FOR SPEEDING PRODUCTION



PILOT HYDRAULIC POWER PRESS

- ★ Occupies only 3 sq. ft.
- ★ Weighs only 10 cwt.
- ★ Develops up to 12 tons pressure.
- ★ Compact and sturdy build.
- ★ Operator's hands free at all times.
- ★ Extreme sensitivity of ram control.
- ★ Automatic action and foot control.

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ENGINEERING AND WELDING EXHIBITION
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PILOT WORKS LTD. (INCORPORATING M. EDWARDS & SONS) MANCHESTER ROAD, BOLTON, LANCASHIRE. **TELEPHONE: BOLTON 5545/6/7.**

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" Transparent " forms a clear solution, through which the work can be seen, and rapidly settles out contaminants, metal particles, etc. The solution keeps the grinding-wheel clean and prevents rust, and its use enables finer and harder wheels to be employed. It does not go rancid, gum the slides, or leave deposits on machines.

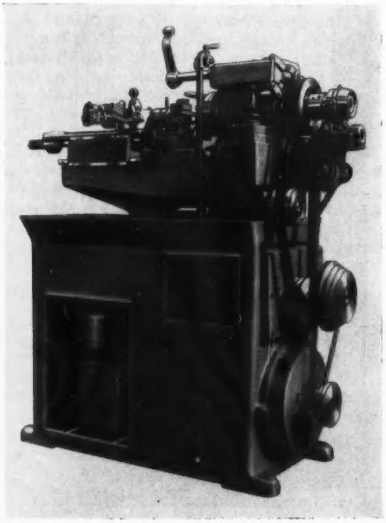
" Transparent," which contains, amongst other things, corrosion inhibitors, chemical emulsifiers, and wetting and softening agents, is readily miscible with water, and is made in different grades to suit particular conditions. Dilutions vary from 80 parts of water to 1 of " Transparent," to 200 to 1, according to the grade and the type of work.

A new high-speed capstan lathe, the " Murad " 1B, will be included in the exhibits of **Murad Developments Ltd.,** of Stocklake, Aylesbury.

In this model, 16 spindle speeds are available in 4 groups of 4 speeds. Any one of the four speeds in each group can be obtained, forward or reverse, without stopping the spindle. Spindle speeds range from 62 to 1800 rpm.

A 2-speed change-pole motor drives a 2-speed gear box and thence the drive is taken to the main spindle via a dual V-rope drive.

Choice of motor speeds is controlled by 2 pedals in the sunk panel at the base of the machine. Speed changes in the gear box are controlled by the lower lever at the left of the operator. There are 3 control positions, *viz.*, high, low, and neutral. In the neutral position, inward pressure on the lever applies the spindle brake. The brake cannot be applied when the lever is in either of the other two positions.



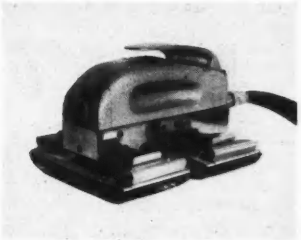
The brake is automatic in its action, and is applied when the reversing lever reaches the neutral position. It is also automatically applied when the motor stop-button is pressed.

Another new feature is the provision of automatic feeds to the turret slide. 6 rates of feed are available. Engagement is by drop-worm mechanism and the feed is automatically released by the turret-slide stops. The feed can also be released at any stage manually by the operator.

The gear box is driven by a separate motor driving via an adjustable spring-loaded overload safety clutch. All gears are automatically lubricated by a plunger type cam operated pump. Similarly, all gears and bearings in the apron are automatically lubricated and need no attention.

A four-way tool post is standard equipment, and a swinging stop and adjustable rear tool post are incorporated in the machine.

In the field of pneumatic sanding machines, **Shipston Engineering Co. Ltd.,** of Shipston-on-Stour, Warwickshire, will be exhibiting the latest addition to their range, the " Johnson " Model S-9, shown in the illustration.



This model is larger than the " Sundstrand " twin-pad sander or the " Wunpad " single-pad sander, and its purpose is to undertake running-down operations on large, mainly horizontal surfaces, where it is desired that the weight of the machine should supply the main force for the cutting action. It is suitable for production finishing of curved or flat wood, metal, or plastic surfaces, and a built-in flushing attachment equips it for either wet or dry sanding, as desired. Opposed, straight-line reciprocation of the double pads produces a natural with-the-grain movement, and the actuating lever is so positioned that the machine operates by palm pressure in the working position.

Shipston Engineering Co. Ltd. will also be exhibiting a wide range of standard lubricators, filters, and regulators, including micro-fog lubricators and three new models of regulator, *viz.* a modified standard regulator with built-in relief valve, a liquid pressure regulator, and a precision regulator for very accurate control of air pressure under low flow conditions.

A comprehensive selection of equipment will be exhibited by **Tangyes Limited,** of Birmingham, including a range of diesel engines, sleeving and utility presses and a wide range of pumps for different purposes.

Also exhibited will be a range of hydraulic jacks, including the new " Hydralite " lightweight jack illustrated, which has been designed for use with oil, instead of water, ensuring that no deterioration takes place in storage. The jack is supplied in a variety of sizes, with capacities ranging between 15 and 50 tons, with corresponding weights between 24 and 59 lb. The operating lever has been kept short (30 in.) to facilitate operation in confined spaces. The approximate effort required to lift full load is 110 lb.

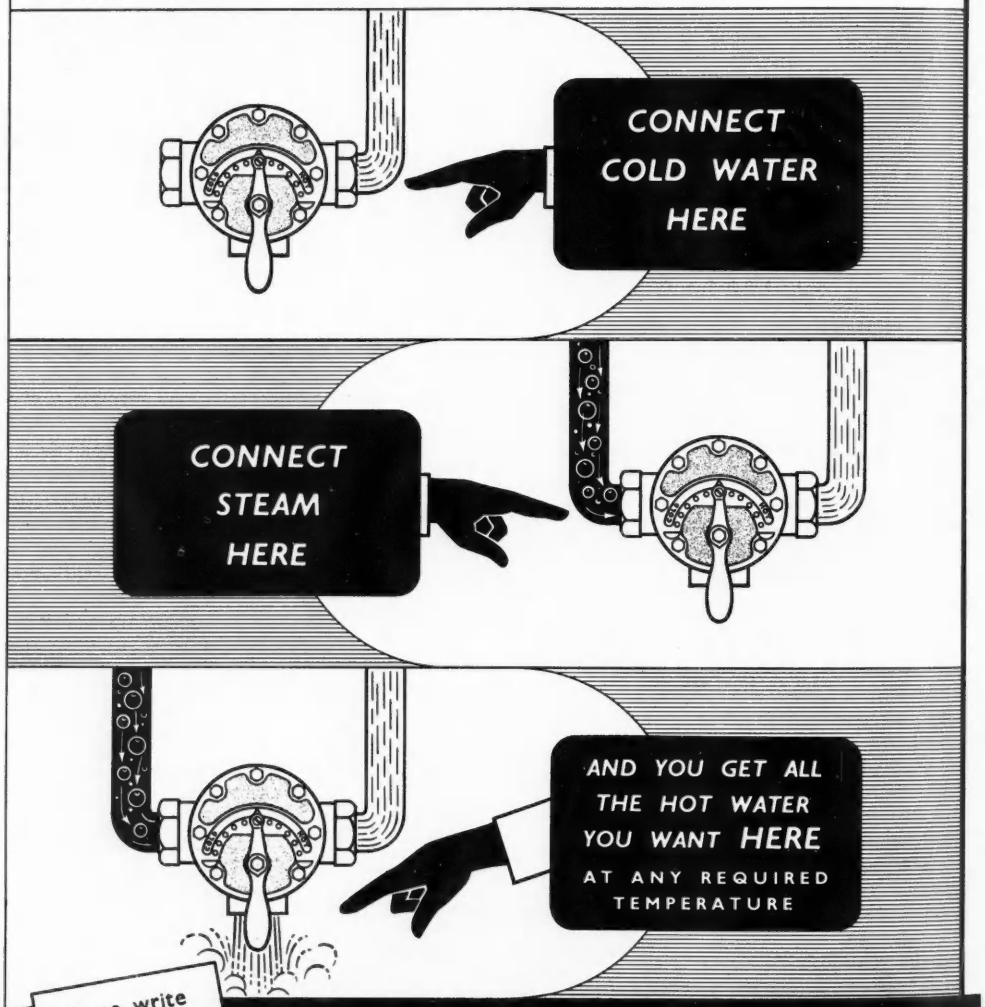
In addition to the wide range of electric and pneumatic tools to be exhibited by **Desoutter Brothers Limited,** of Hendon, will be two new series of pneumatic straight drills of $\frac{3}{8}$ in. and $\frac{1}{2}$ in. capacity, fitted with type S.R. pneumatic motors, which develop over $\frac{5}{8}$ bhp. The latter can be claimed to be the smallest and lightest portable tool of its type in existence, its weight being half that of any other tool in this capacity. The $\frac{1}{2}$ in. drill is illustrated.

Among the new features of these drills is an adjust-

Leonard THERMOSTATIC

steam-water HEATER

- Easy to install
- Low Initial cost
- No heat storage losses



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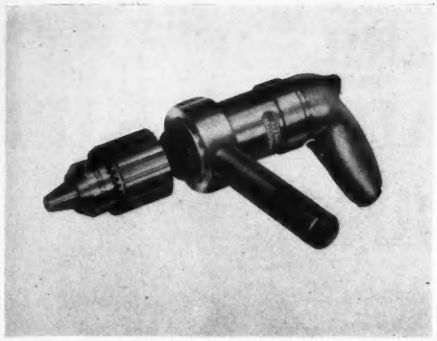
WALKER CROSWELLER & CO., LTD.
Whaddon Works, Cheltenham Glos.



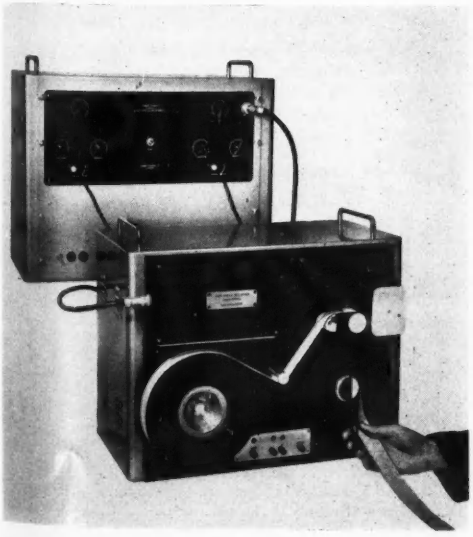
able exhaust deflector sleeve, which can be rotated to blow the exhaust air away in any direction—and a detachable side handle, which can be quickly adjusted to suit the particular drilling operation. This attachment is a standard fitment to the $\frac{1}{2}$ in. drills, but is also available as an extra for the $\frac{3}{8}$ in. models, if required.

Other new tools to be shown for the first time will be a new series of powerful corner drills capable of drilling $\frac{5}{16}$ in. holes in steel to within $1\frac{1}{2}$ in. of the inside face of a right angle, a light and compact corner nut-runner specially designed for running down nuts in almost inaccessible locations, and a more powerful type rivet miller of $\frac{1}{2}$ in. capacity.

Included in their wide range of engine indicators and peak pressure instruments, **Dobbie McInnes Ltd.**, of Glasgow, will be exhibiting an improved "Farnboro" indicator for high-speed engines and a new, reasonably priced diesel engine indicator valve, having no packing of any kind.

In addition, their latest Poise-meter for indicating, recording, and controlling viscosity will be demonstrated.

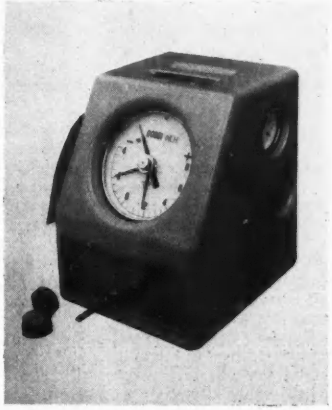
In the field of electronics, three new instruments will be exhibited for the first time. The first of these is a high-speed plotting table, in which a pen is driven by servo-motors in two directions (X and Y co-ordinates) simultaneously over a record surface of 18 × 30 in. The ordinate and abscissa are proportional to input voltages, and the writing speed is up to 15 inches per second, with an accuracy of ± 0·2 per cent.



The second instrument is the high-speed recorder illustrated. It records directly on paper any varying quantity up to 2000 cps, with a high paper speed of as much as 20 fps. Even square waves are recorded as accurately as sine waves. There is no inertia and, with the exception of the paper drive, no moving parts. Accuracy is ± 1·5 per cent and a special advantage is that permanent records are in the operator's hands almost immediately.

The third new instrument is an electro-mechanical multiplier unit, specially useful in computing work. This device permits multiplication accuracies of ± 0·2 per cent at, for example, 0·2 cps. The maximum multiplic and voltage for each of 5 channels is 700.

The Mercer "Pneugauge," to be exhibited by **Messrs. Thomas Mercer Ltd.**, of St. Albans, is an instrument capable of working to the extremely close limits demanded by modern production, with the minimum of operative skill and at speeds hitherto unobtainable.



As its name implies, the Mercer "Pneugauge" is an air-operated instrument, designed to meet the needs of present day production gauging problems. It provides magnifications up to 10,000, with stability far in excess of comparable instruments. Designed for the measurement of small diameter bores, the instrument is available with attachments for the measurement of external diameters, thicknesses, etc.

The Avery direct-reading Brinell hardness testing machine No. 6405, to be exhibited by **W. & T. Avery, Limited,** of Birmingham, has been developed to provide a rapid and reliable method of control of heat treatment. At the same time, all the features of the Standard Brinell test are retained.

A dial indicator measures the depth of the Brinell impression on the established principle of difference between impressions produced by major and minor loads. The method used eliminates the effects of surface roughness, and satisfactory readings can be obtained on surfaces produced by shot or sand blasting. The impression is a true Brinell impression, and can be checked by microscope.

Also exhibited will be the Avery visual hardness testing machine No. 6406, illustrated, designed for making tests on materials as varied in nature as hardened steel and lead. The machine is equipped for both Brinell and Diamond Pyramid testing. Since accurate results are obtained with a slight impression when the Diamond Pyramid test is used, the machine is of great value where thin specimens of finished components are to be examined, since there is no serious surface disfigurement.

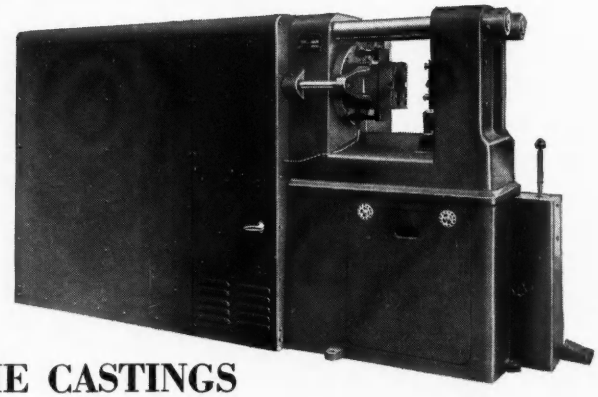
A built in microscope and an arrangement which projects the enlarged image on to a ground glass screen,

"THE NEW SERIES II"

COULTHARD MADISON-KIPP

MODEL 400 & MODEL 450 HI-PRESSURE DIE CASTING MACHINES

MODEL 400
CAPACITY up to
1·13 lbs. in ALUMINIUM



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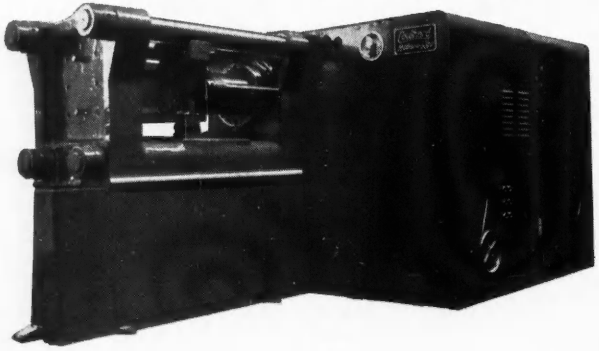
HIGH PRESSURE DIE CASTINGS

Some Outstanding Features of the New "Series II" Die Casting Machines . . . Greatly Increased Output, Perfect Control, Increased Holding Power, Higher Injection Pressure, Streamlined Power Unit, Automatic Shutdown. In the event of a pressure drop in the hydraulic system the current is automatically cut off, stopping the motor and pump, and the high pressure nitrogen cylinder is isolated preventing the escape of oil and nitrogen. New Valve Block, Oil Filter.



Model 450
CAPACITY up to
3 lbs in ALUMINIUM

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DURRANHILL ROAD • CARLISLE • ENGLAND

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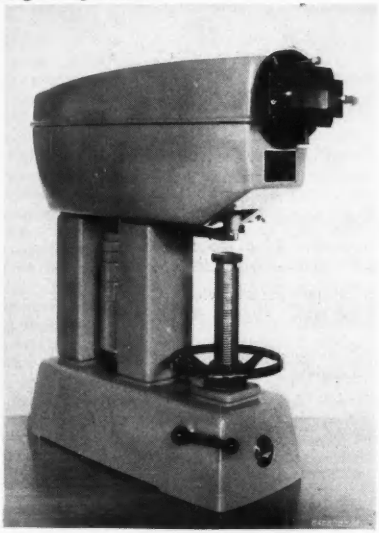
where it can be measured to 0·001 mm, makes the apparatus ideal for rapid repetition testing on the production line, as well as for tests on individual specimens. Up to 300 comparative tests an hour can be made, depending on the character of the work. The impression is automatically magnified and projected onto the screen, and measurement can be made without removing the specimen.



Included in the exhibition is a range of electrodynamic balancing machines. These are designed for determining the amount of unbalance in a rotating body and automatically indicating its position. The time required to determine the amount of unbalance is negligible, and the " floor to floor " balancing of a rotor is rapid and simple.

The machine indicates either the amount of correction necessary at two preselected positions in each of two planes, or the actual amount and position of unbalance in each plane. High sensitivity is obtained without electronic amplification. There are no delicate or easily damaged mechanical parts ; construction is robust and simple.

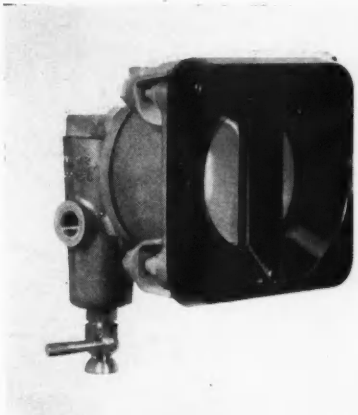
The 7210 model exhibited is for balancing rotors weighing between 6 and 600 lb, while the 7206 bench-mounted model, working on the same principles, is for rotors between 3 oz and 20 lb.

Included among their comprehensive range of air compressors, pressure reducing and relief valves, and other pneumatic accessories, **Williams and James (Engineers) Limited,** of Gloucester, will feature the " Pneumerstat."

This instrument combines the duties of a bubbler chamber, pressure reducing valve and needle valve, for use on applications to control the supply of compressed air when this is used for purposes such as the indication of content, level or pressure.

It can also be used for the regulation, with great accuracy, of a slow feed of water for laboratory tests, and in the continuous sampling of gas for analysis of shed atmosphere and absorption tower outlets, etc.

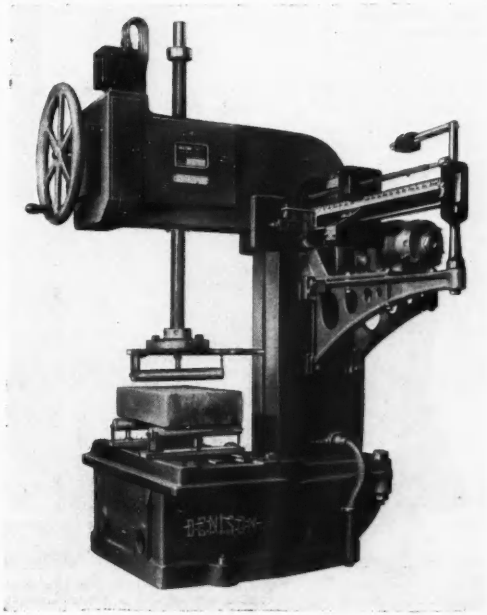
The " Pneumerstat " gives constant airflow, and can be used for open or closed vessels working under pressure or vacuum. It enables level to be indicated during blowing-down operations and it can be used for purging lines. It reduces the number of components required in an installation, thereby reducing installation costs, and, due to fewer joints, it helps to prevent air leaks.



As shown in the illustration, the " Pneumerstat," which is designed for panel mounting, has a pleasing appearance.

Included in the wide range of testing and weighing machines exhibited by **Saml. Denison & Son, Ltd.,** of Leeds, is the Denison Model T.30C compression and transverse testing machine illustrated.

This machine has a maximum capacity of 10,000 lb and is completely self-contained, requiring no special foundations. It is designed on the weighing lever principle, and the load on the specimen is applied by means of a handwheel and non-rotating straining screw on the front of the machine. The indicator mechanism is of the steelyard type, and is fitted with a motorised poise-weight, so that uniform rates of loading can be applied. An adjustable tare bar is incorporated for the purpose of balancing-off the weight of the tackle and specimen before testing. There is also an automatic knock-off switch for stopping the motor when the specimen fractures.



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RANGE OF
ABRASIVE WHEEL
CUT OFF MACHINES
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For faster, cheaper, better production. Will cut Bars, Sections, and Tubes in most materials ; cut square, mitre or compound angles in a matter of seconds.
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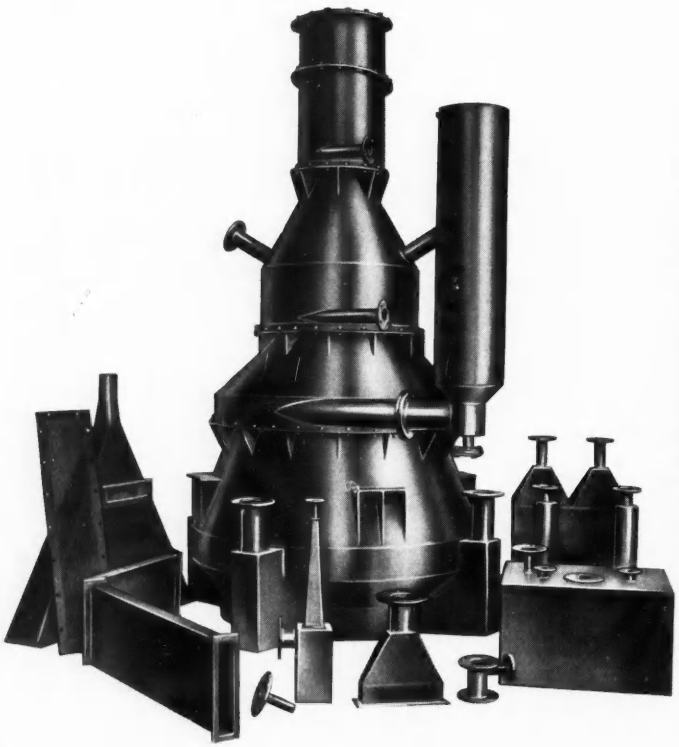
Swivelling head for mitre cutting. Length stop bar. Screw-operated vice. Optional air-operated vice gear. Bench type or Floor stand available. Write for details of complete range.
FOR CUTTING GAS TURBINE BLADE AND OTHER DIFFICULT MATERIALS THESE MACHINES ARE UNSURPASSED.
L.J.H. BALLINGER LTD.
WOODCHESTER, STROUD, GLOUCESTERSHIRE, ENGLAND.



This vessel, approximately 18′ - 0″ in height is constructed from $\frac{3}{16}$″ to $\frac{3}{8}$″ Plate and is typical of the class of work done by us.

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ON THE ADMIRALTY AND MINISTRY OF SUPPLY LIST.

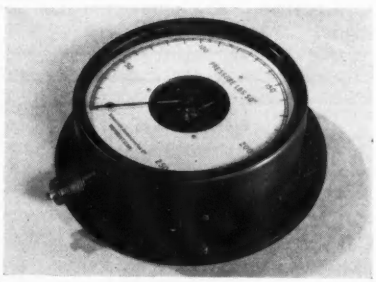
The main column carrying the straining gear and the load-indicating mechanism is of the over-hung type, thus giving easy access to the specimen table. All controls are on the front of the machine, so that the operator can keep both the indicating mechanism and the specimen under easy observation.

Standard electrical equipment supplied with the machine is for 400 volts, 3 phase, 50 cycles.

This machine was specially designed for tests on pre-cast concrete kerbs, edgings, flags, etc., to comply with British Standard Specifications.

Among the wide range of gauges exhibited by **Simmonds Aerocessories Ltd.,** of Treforest, Glamorgan, is a new type of pressure gauge, which is an entirely new development, different in construction from conventional Bourdon tube instruments.

Known as the Simmonds " Resilient Strip " pressure gauge, the new gauge, shown in the illustrations, incorporates a resilient strip of high flexibility, designed to withstand an overload of 100 per cent, without inducing a fibre stress even remotely near the limit of the material itself. The strip consists of two thin, stainless steel strips, stitch-welded along two edges and one end. The assembly is subsequently formed to a conventional arcuate shape. The material of the resulting shallow flat section tube is of relatively high tensile strength and its flexibility remains constant over a wide range of pressure loads. The main advantage of this construction is that the fibre stress in the walls, for a given deflection, is very much lower at all parts of the section than would normally be the case. This advantage is obtained from the geometry of the strip, combined with the use of stainless steel.



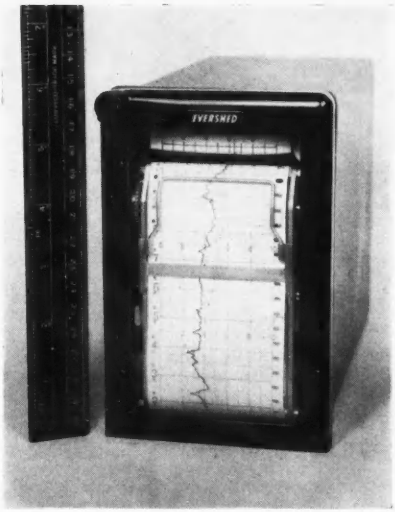
The grooved pointer spindle is mounted between jewel bearings and in operation the complete instrument works with extremely low frictional loss and near " dead beat " movement.

These gauges will be available in the usual range of sizes, in " flanged " and " plain " types. The bottom entry connecting union is in standard British threads, in accordance with usual practice.

Amongst other products exhibited by **Evershed and Vignoles Limited,** of Chiswick, London, are two new recorders (high-response and miniature respectively) and a mains-operated insulation tester.

The high-response recorder has been designed to fill the gap between their standard recorder and the more elaborate amplifier-operated quick-response recorder. By means of a re-designed magnetic system, the torque has been increased to about eight times that of the standard recorder. Adjustable magnetic damping places any degree of damping, to suit the test in progress, at the disposal of the operator.

The miniature recorder, shown in the illustration, has been developed for use mainly with process control apparatus, for recording physical and other quantities detected by various forms of electronic transmitter. It is a moving coil milliammeter with a small, continuous roll chart, with a 2 in. wide scale, driven by a synchronous motor at a speed of 0·5 in. per hour. The record is made by a high-speed tapping mechanism



using an inked ribbon. The overall dimensions of the front, flush-mounted in a panel, are approximately 6 in. × 4 in.

In the mains-operated insulation tester, the generator has been replaced by a static rectifier, operating from a.c. mains in conjunction with a step-up transformer. Three testing voltages are available, *viz.*, 1000, 2500, and 5000, the required voltage being selected by a switch on top of the instrument.

A new wrought alloy, " Corronel B," containing approximately 66 per cent Ni, 28 per cent Mo, and 6 per cent Fe, is being exhibited by **Henry Wiggin & Company Limited,** of London.

The new alloy has reasonable ductility and maintains a high proportion of its strength at high temperatures. Its strength and hardness figures are high and comparable with those of alloy steels. By virtue of its molybdenum content, " Corronel B " ranks as a relatively noble alloy. In consequence, it does not evolve hydrogen readily, even from concentrated solutions of acids, and, in this connection, it is highly resistant to hydrochloric acid at all concentrations and temperatures, and to corrosion by phosphoric acid, particularly favourable results being obtained at temperatures approaching the boiling point. Furthermore, it has adequate resistance to attack by all concentrations of sulphuric acid and is extremely resistant to corrosion by many other media, such as organic acids, calcium chloride, brines, etc.

The high degree of corrosion-resistance exhibited by " Corronel B " makes it suitable for application in the chemical, drug, and petroleum industries. Another important application is to be found in the development associated with the pickling of various metals, and such items as pickling tanks and steam heating coils for pickle baths.

The alloy is regularly available in sheet form, of maximum width 3 ft, in any gauge down to 16 swg, and in any length which can be accommodated in a weight limit of 120 lb. Sheet, 1 ft in width, can be produced down to 24 swg. Rod, of 2 in. diameter or less, can be supplied as extruded or hot-rolled. Bar, of more that 2 in. diameter, is produced by hot-rolling or forging. Tubing is supplied seam-welded and may be produced in most sizes likely to be required commercially.

The system of high-temperature heating, exhibited by **Hygrotherm Engineering Ltd.,** of London, is a method of heat transfer which embodies certain

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Lift Safely

Vaughan

Electric Hoists

A.C. ONLY

The New series EB52 Electric Hoist Blocks with a load range of ¼-5 tons are specially designed to

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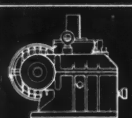
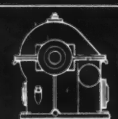
Type **F.S.W.R.** Upright fan-cooled worm reduction units. *For ratios between 5 and 60 to 1*

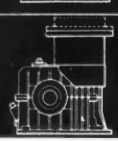
Type **F.I.W.R.** Inverted fan-cooled worm reduction units. *For ratios between 5 and 60 to 1*



Type **F.V.W.R.** Vertical fan-cooled worm reduction units. *For ratios between 5 and 60 to 1*



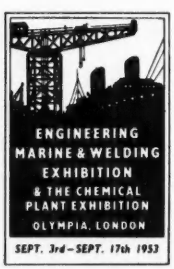
Type **D.W.R.** Double reduction worm gear units. *For ratios between 60 and 3000 to 1*



Type **F.M.V.W.R.** Vertical geared motor worm reduction unit. *For ratios between 5 and 60 to 1*

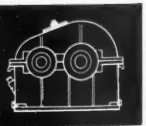
WISEMAN

The name for Standardised gear units

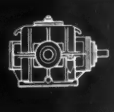


STAND No. 5
OUTER ROW GALLERY
GRAND HALL

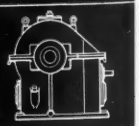
Type **S.R.-W.** Single reduction spur unit. Wide type. Also S.R. narrow type and D.R. double reduction spur or helical units.



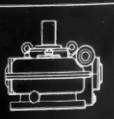
Type **S.B.H.** Single reduction bevel type units. *For ratios between 1 to 1 and 4.5 to 1*



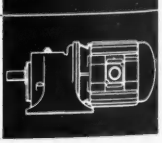
Type **R.A.D.R.** Double reduction spur and worm unit with Right-Angle drive. *Ratios 60 and 300 to 1*



Type **D.V.W.R.** Double reduction worm units with vertical output shaft. *For ratios between 60 and 3000 to 1*



Type **G.M.-D. and G.M.-T.** Double and Triple reduction geared motor units. Horizontal and vertical types. Range ½ h.p. to 30 h.p.



Please ask for catalogue ED/102 which gives a complete list of gear units with full specification, overall dimensions and H.P. Capacities.

ALFRED WISEMAN & CO. LTD. Glover Street, Birmingham, 9. London Office: Carlisle House, Southampton Row, W.C.1

features peculiar to liquid heat systems, and which basically offers to the chemical engineering field a simple and effective means of heat transfer up to temperatures of 650° F, by means of an organo-silicate liquid.

The liquid used has formed the subject of research over many years, and the last four years have been used to develop suitable systems in which it can be employed, the basic principle being to ensure adequate heat transfer, coupled with long life of the liquid in the system. The properties of the liquid are such that standard centrifugal pumps can be used to circulate the liquid through the system, and it has low temperature characteristics which ensure that, down to 0° F, there is no need to provide any additional steam or electric tracing to ensure that the liquid remains mobile.

As the liquid tends to hydrolise in the presence of moisture, it is, therefore, necessary to use it in a closed pipe system with means provided for expansion. The liquid is non-toxic and has a very low fire hazard, so that the risk of damage to the installation by fire is very greatly reduced, as compared with other high temperature heat transfer media.

A new liquid, with improved characteristics, is being developed. This is more resistant to hydrolysis, and is suitable for operating at temperatures up to 750° F.

This method of heating can be compared in some respects with oil heating, the advantages being the greater life of the liquid, the absence of coking or sludging of the material, particularly in the heat generator, the greater mobility of the fluid, permitting the use of centrifugal pumps and giving better heat transfer at lower temperatures, and the lower fire hazard, as this material will burn only with difficulty, and will extinguish itself on coming into contact with a cooler surface.

Included among the exhibits of **Newton Victor Limited,** of London, is a range of specially developed radioactive isotope containers embodying unique remote-control facilities. For the first time, an industrial isotope container for 1 curie of cobalt is offered, so designed that the tolerance dose is not exceeded on the surface of the container. The same container, moreover, can be used for radioactive sources up to 4 curies, with the tolerance dose not exceeded at a distance of one metre.

The special remote control feature of these containers not only ensures the highest possible degree of safety for the operator, but very greatly increases the flexibility and convenience of application of the radioactive source in a wide variety of industrial processes, including, for example, the gamma-radiography of the hull of a ship afloat.

The new range of containers includes a smaller unit, also available with the special remote-control feature, for iridium sources of any strength, or for a cobalt source of up to 0·5 curies—and a still smaller unit to accommodate a thulium source, suitable for light-alloy examination, and specially useful in the aircraft industry.

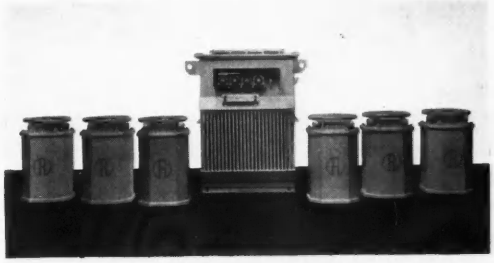
Also shown for the first time in Great Britain is the Newton Victor "Raymax 150" gas-insulated industrial X-ray equipment, designed for operation at 150 kV peak, 10 mA. In this unit, the X-ray tube and transformer (assembled in a single, compact steel tube-head of extremely light weight) are insulated with sulphur hexafluoride gas. The tube anode projects from the tubehead tank, so that it can be introduced conveniently into hollow castings, pressure vessels, pipes, etc. The tubehead is mounted on a small gantry, providing a wide range of movements and from which it can be quickly detached for on-site radiography. This new equipment will greatly simplify the radiography of welded joints in difficult situations on pipelines, penstocks, and all open construction sites.

In addition to a wide range of normal and precision castings and of "Stellite" faced components for every industry, **Deloro Stellite Ltd.,** of Shirley, Birmingham, will be exhibiting for the first time two new rods, Alloy "C" and Delcrome.

Alloy "C" is a nickel-molybdenum-chromium alloy, manufactured in the form of plain and coated welding rods for depositing purposes, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$, and $\frac{1}{4}$ in. in diameter.

It is very resistant to oxidation at high temperature and retains its hardness and strength to an exceptional degree at temperatures up to 1200° C. As it is softer and more ductile than the cobalt base "Stellite" alloys, it possesses greater resistance to thermal and mechanical shock. An important property is its capacity for work hardening under repeated impact stresses, thus making it particularly suitable for repairing dies and punches for drop forging. Hardness-D.P.H. is 200-250, ultimate tensile strength 30 tsi, yield point 20 tsi, and elongation (on 2 in.) 10-15 per cent.

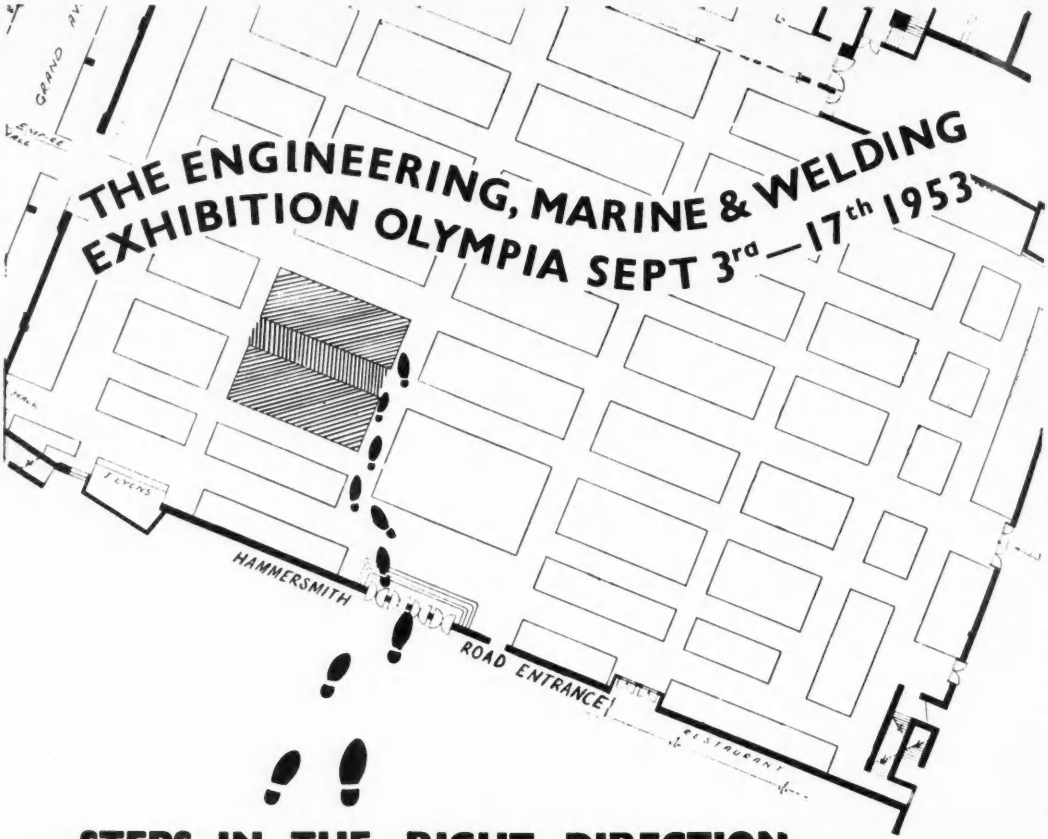
Among many new types of electrode exhibited by **Rockweld Ltd.,** of Croydon, five merit special mention. These are: (1) "Vitrac," specially developed for economical welding, particularly in the shipbuilding industry. (2) "Mixend 55," a 55 per cent nickel alloy electrode, designed for welding semi-ductile cast iron of the spheroidal graphite type, though it is also suitable for making strength welds in normal grades of cast iron. (3) "Chromolac 1A," specifically designed for the welding of 1 per cent Cr, 0·5 per cent Mo steels. (4) "Chromac N," an electrode with an 80 per cent Ni, 20 per cent Cr core wire, for welding heat-resisting alloys used on jet and gas-turbine components. (5) "Silvac," for use on mild steel fabrication where surface appearance is of primary importance.



Also exhibited is a complete range of multi-operator welding plant and a duplex regulator, capable of supplying two operators up to 350 A or one operator up to 700 A. The illustration shows one of these multi-operator, a.c. welding transformers, type MT95, and a group of six regulators, type MNR350.

Among new developments exhibited by the **Quasi-Arc Company, Ltd.,** of Bilston, Staffordshire, will be a small, low-priced, single operator diesel welding set. The engine develops 11 hp at 1650 rpm, and the V-belt drive is so arranged that the engine pulley may, if desired, be used as a power take-off for driving small machines, when not required to drive the generator. Current regulation is stepless and the generator provides a suitably regulated output, permitting easy deposition of all types of electrodes (sizes 16-6 swg) within the current range of 25 to 180 A. Although normally supplied with four hard-steel floor-locating pins, rubber mountings may be fitted, if required.

Also exhibited is what is claimed to be the first British-made selenium plate metal rectifier welding set, shown in the accompanying illustration. This set takes a balanced 3-phase input, specially designed for the remote control of the full welding current range of 25 to 375 A, by means of a single control knob. Remote control of welding current is fitted as standard equipment, enabling the operator to have full current adjustment at the point of welding. The set is fan-cooled,



STEPS IN THE RIGHT DIRECTION

TUFNOL LIMITED

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GROUND FLOOR · NATIONAL HALL

GEORGE **ELLISON** LIMITED

STAND NO. 7 ROW Q

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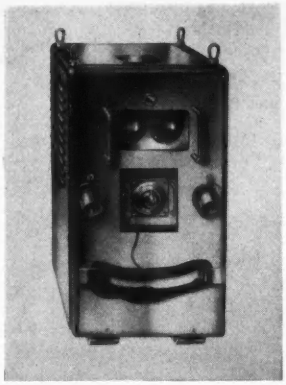
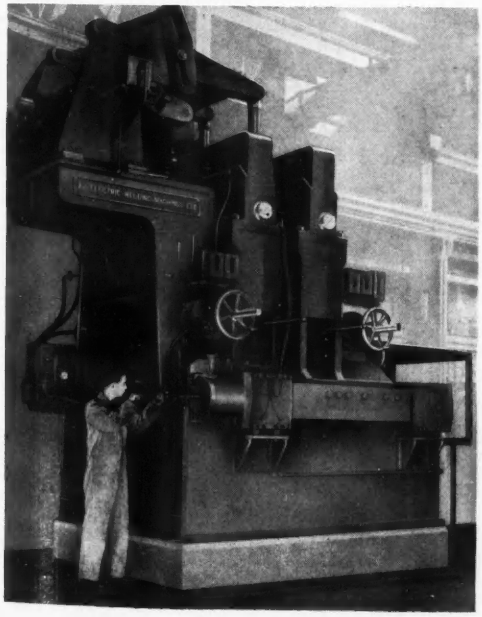


is almost silent in operation, and will supply the maximum welding current of 375 A at 30 arc volts at a 50 per cent duty cycle. Current regulation is stepless and the stable volt-ampere characteristics of the d.c. output permit all types of electrodes within the current range to be deposited easily. The set may be supplied with or without wheels, ammeter, and voltmeter.

Latest developments, particularly in the flash butt welding field, are being exhibited by **A.I. Electric Welding Machines Ltd.,** of London.

For the railways and carriage and wagon industries, their new range of general purpose automatic flash butt welding machines is of particular interest. These machines have been designed to cover a wide variety of assembly operations in these heavy industries,such as buffers, foundation rings, 3-link couplings, brake beams, etc. Several new features are incorporated in these models, particularly the new patented air/oil intensifier system, which obviates entirely the use of hydraulic pumps and accumulators. This new automatic control system for preheating, flashing and forging, has proved most useful in eliminating the last stages of manual control of the machine.



For the steel industry a range of automatic strip welding machines is available for strip widths from 2 to 74 in., with flash trimming machines designed to suit the requirements of the modern steel mill. The 42 in. model is illustrated.

(*Continued overleaf*)

APPLIED RESEARCH AT EXTREMELY LOW TEMPERATURES

(*Concluded from page* 282)

remove energy from them. This energy loss is therefore temperature-dependent and should reach zero at absolute zero. In practice, however, the electrical resistance does not generally extrapolate to zero but approaches a small and finite value called the residual resistance. This residual resistance is due to imperfections in the crystalline lattice (i.e., places where the regularity of the lattice has been destroyed by crystal faults, grain boundaries, etc.) or due to actual impurity atoms present in the metals. Thus, residual resistance is now used as a measure of the amounts and rôle of impurity in a metal and of its past metallurgical history. For example, the annealing kinetics of cold-worked copper and the recovery kinetics of cold-worked zirconium have recently been determined by electrical resistivity measurements at very low temperatures.

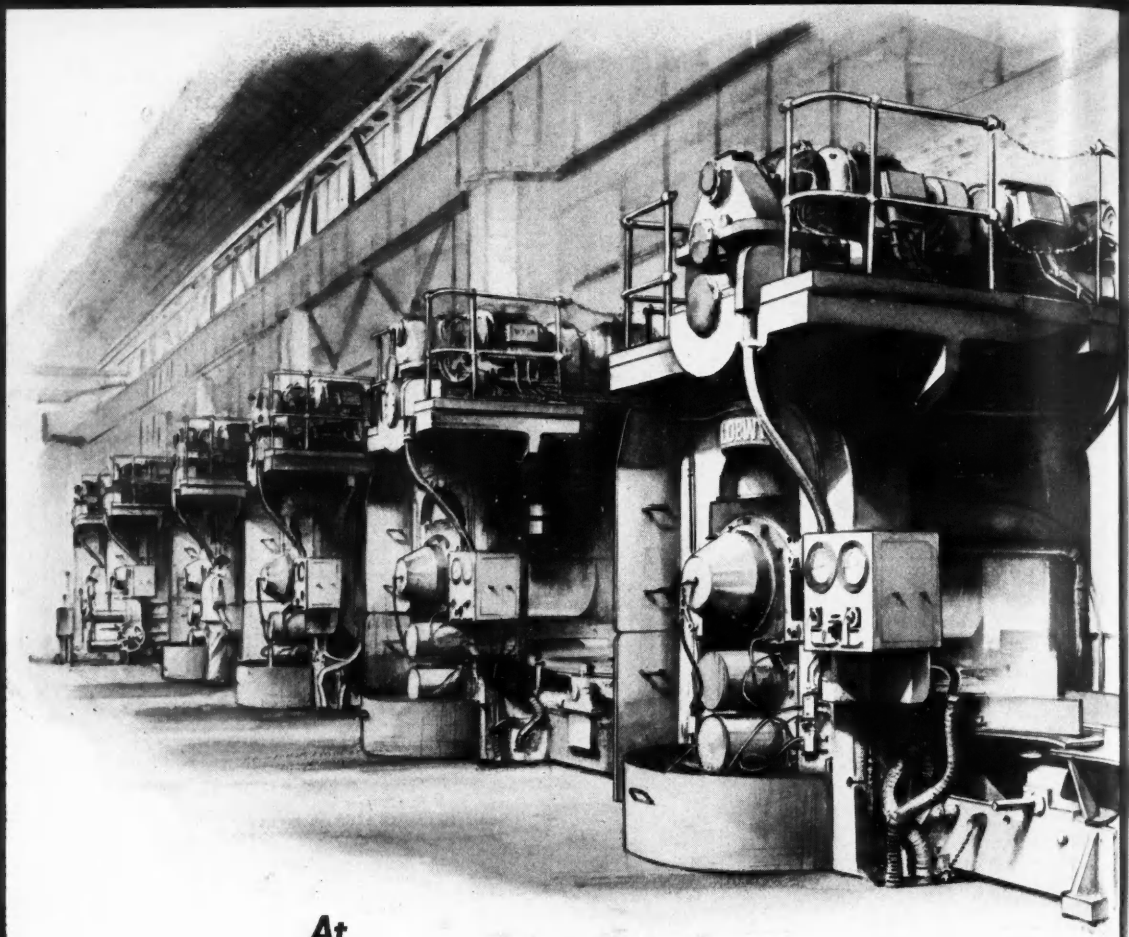
Many inconsistencies were found in comparing results of different early workers, and their cause was not really evident. Recent low-temperature electrical resistance studies have shown that two samples of the same substance, outwardly identical, may contain traces of impurity not detectable at higher temperatures. The effect of adding impurities in ever increasing amounts results in a study of the properties of alloys, and much low-temperature metallurgy is being directed along these lines.

Corrosion and oxidation of metals have been completely stopped at very low temperatures. Thus, one would expect the region near absolute zero to be one of complete molecular inactivity, of complete and perfect stillness. Nature, however, has provided boundless surprises for the scientist, many of them in the phenomena which occur at liquid helium temperatures, phenomena which, far from having the character of stillness, are characterised by the greatest freedom of motion ever encountered in physical science.

One of these, the conversion of certain metals and compounds into superconductors, is perhaps of more immediate interest to physicists, but it also may aid the metallurgist in a more complete understanding of the behaviour of metals. As previously mentioned, the electrical resistance of metals should gradually decrease to zero at absolute zero. However, the resistance of a few metals, including some which are poor conductors at ordinary temperatures, vanishes completely at some characteristic temperature above absolute zero. It may be difficult to imagine a piece of lead carrying a current better than a copper high tension line, but if a current were started in a piece of lead at -446° F (8° K), it would tend to flow indefinitely without a battery.

Another example of increased motion at extremely low temperature is the superfluidity of liquid helium, already mentioned, at $2{\cdot}19^\circ$ K. The apparently frictionless flow of liquid helium under these conditions enables it to creep over surfaces at remarkable speed. Experiment has shown that the rate of creep of this superfluid helium film is contingent upon the state of a surface and may be used to control the processing of a surface.

While many of the direct connections which exist between the room temperature properties of metals and alloys and their low-temperature behaviour have yet to be exploited, the small amount of low-temperature data already in existence has added considerably to our knowledge of the science of metals.



At

FORGES de la PROVIDENCE
REHON, FRANCE

The artist's drawing shows the finishing stands of the continuous hot strip mill for rolling steel strip up to 24 inches wide, which was supplied by THE LOEWY ENGINEERING COMPANY LIMITED, LONDON.
The back-up and workroll necks of all six finishing stands are mounted on Timken tapered-roller bearings, made in England.

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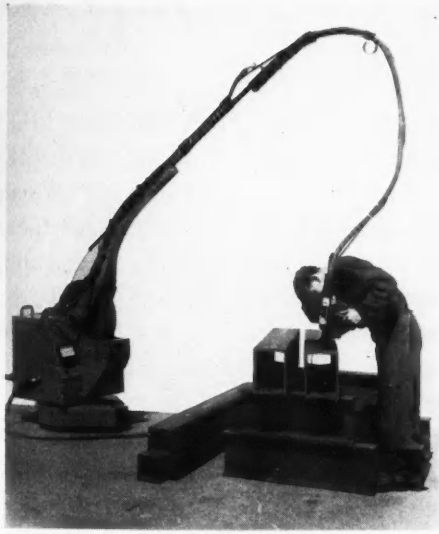
TIMKEN TAPERED-ROLLER BEARING

For the metal window industry, new models of automatic mitre and reverse bar welders have been developed, with new features designed to give high speed production. For the automobile industry, high-powered machines for motor wheel production are available, with full information relating to welding performance and production times.

In the field of electric resistance heating, new developments are typified in the A.I. automatic electric pipe heating machine, which provides an economical method of heating pipes for bending operations.

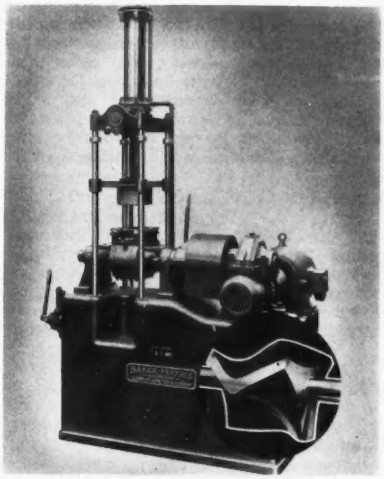
In the Fusarc Manual Continuous Welder, exhibited by **Fusarc Limited,** of Gateshead, Durham, a specially designed manual continuous welding head is used in conjunction with a specially designed control box, as shown in the accompanying illustration. The base is mounted on castors, and carries the box, which itself can rotate through 360 deg., thus enabling the whole control box to be easily moved to suit welding shop requirements. The control box is fitted with a counterbalanced arm, which supports the hollow electrode carrying cable to the welding head, relieving the welder of the weight of the cable, giving greater freedom of movement, and keeping the floor area free from all control cables. Radius of operation is from 3 to 15 ft, through 360 deg.



The continuous welding head comprises a drive unit which fulfils the two main functions of feeding the electrode and traversing the welding head through a pivoted power-driven castor wheel. Both these functions are independently regulated by thumb controls conveniently situated on the right and left handles of the machine. The welding conditions for a particular job can be pre-set on scales on the upper face of the welding head, and the operator has only to make slight adjustments to the rate of feed as welding proceeds to maintain an even arc length.

The arc is viewed through a built-in arc shield, so that the welder is not inconvenienced by a helmet. A fume disperser, driven from the head motor, helps to blow welding fumes away from the operator.

A display of mixers embracing machines in 19 standard sizes from 1·1 to 2 pints to 2,200 gallons per mixing and including many types and classes, will be exhibited by **Baker Perkins Limited** and **Baker Perkins (Exports) Ltd.,** of London and Peterborough.



The main exhibit will be a Size 12, Type VI/H, Class B.S.C.C. Heavy Duty " Universal " Mixer, which has been specially developed for heavy mixing work, such as pigment or aqueous rubber dispersions, and having a working capacity of 9 gallons, particularly suitable for incorporation in plants for pilot scale production. At the same time, it is generally illustrative of the lines upon which their larger and heavier types of machines are built. It is powered by a 40 hp motor and

(*Continued overleaf*)

AUTOMATIC ARC WELDING OF HELICALLY WOUND TUBES

(*Concluded from page* 294)

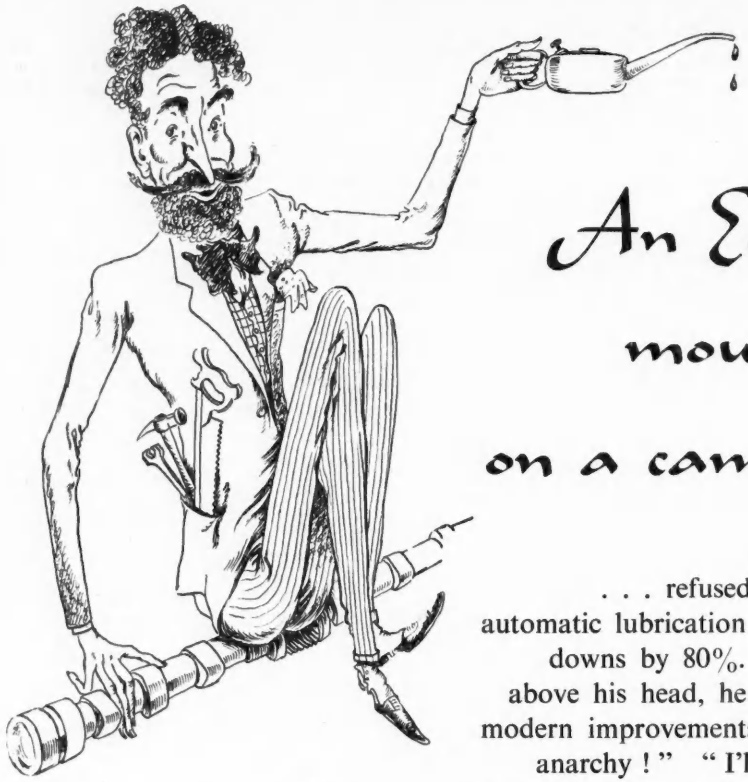
The cut tube lengths have their ends faced on a special machine and the finished tubes undergo a hydraulic pressure test.

The whole installation, excluding the finishing section, is controlled by seven men, namely, three operators, three welders, and one cutter. This number is only a fraction of that required in the manufacture of seamless tubes.

The feeding of the welding arc of either of the two welding heads for the helical seam proceeds from one or two d.c. generators, according to the conditions of welding. An automatic device carries out the switching and starting of the two individual generators. The preliminary feeding of the electrodes until contact with the unwelded tube is established is effected by pressing an " up " or " down " push button, which, through suitable starters, connects the drive motor of the welding head. Before welding, the operator prepares the working of the control circuits by operating a switch in the central control panel. A contact, normally closed, prevents switching in of the welding circuit when the strip moves in the reverse direction.

Welding begins by pressing the " start " button, thus switching on the welding current through the starter and contactor system. A voltage relay reverses the motor of the welding head for feeding the electrode wire into the welding zone. Simultaneously, the electrical drive for the tube motion is switched on by automatic control equipment, and welding starts.

For stopping the welding process, the " stop " button is pressed and the starter is switched off through a contactor, together with the motor of the welding head. The arc lengthens gradually and after 0·5-0·8 sec a time relay switches off the welding current through the line contactor. Simultaneously, the motion of the tube is stopped through a system of blocking relays.



An Eccentric mounted on a camshaft...

. . . refused to be convinced that automatic lubrication could reduce breakdowns by 80%. Waving an oil can above his head, he shouted, "All these modern improvements lead to unrest and anarchy!" "I'll admit," said the Tecalemit man quietly, "that automatic lubrication does incite machines to more revolutions!"

At this the eccentric became more and more heated and, not having the benefit of automatic lubrication, eventually had a seizure from which he never recovered.

Tecalemit lubrication systems—fully automatic, semi-automatic or manually operated—feed every bearing with the correct amount of oil or grease at the correct intervals of time, regularly . . . unfailingly . . . efficiently. A Tecalemit engineer will gladly call to discuss your particular lubricating problems with you.

TECALEMIT

The Authority on Lubrication

PLYMOUTH, ENGLAND

T394

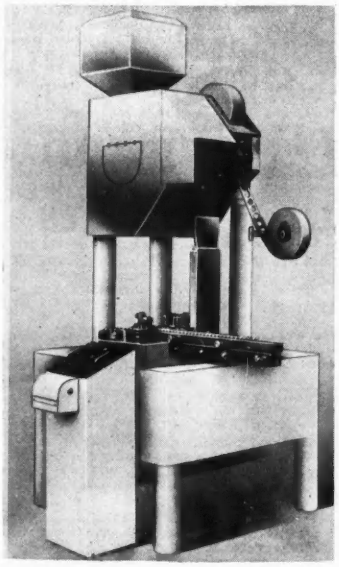
fitted with their " 3-Wing " masticator blades, cored for steam or water circulation. For discharge purposes, the jacketed trough is arranged to tilt by hydraulic cylinder, operated from an independent pressure assembly. Although the trough is provided with a standard type of cover, the machine is so designed that it can be fitted instead with a compression cover or ram, if desired.

Illustrated is another exhibit, the Size 4, Type III, Class B.S.C.C. Heavy Duty " Universal " Mixer which is a smaller edition of the Size 12, as it is also for heavy duty mixing and incorporates similar design features. Its capacity in this design is 0·43 gallons and the main drive is from a 4 hp motor.

Still another exhibit will be the size 4, Type III, class B.S.C. " Universal " Mixer. This is of somewhat lighter construction, and is designed for carrying out a wide variety of laboratory scale mixings, including pigment and allied dispersions. It is fitted in this instance with " single curve dispersion " type blades, has a jacketed trough of $\frac{1}{2}$ gallon working capacity, and is arranged for direct drive from a 4 hp motor, the whole being mounted on a common baseplate for bench use.

Also displayed is the Size 3, Type I, Class B.S. Unit, which is a small machine of 1·1 to 2 pints capacity and is ideally suited as a general purpose laboratory mixer, as it is specially designed so that it can be easily dismantled for cleaning purposes. It is powered by a $\frac{1}{4}$ hp motor, the whole being mounted on a common baseplate for bench use.

A comprehensive range of vial-capping machinery will be exhibited by **Fords (Finsbury) Limited,** of Bedford. The range includes fully-automatic cap-making presses, making vial caps from continuous strip aluminium of up to 0·3 mm gauge. These presses have outputs of up to 15,000 caps per hour, and require no attention during running.



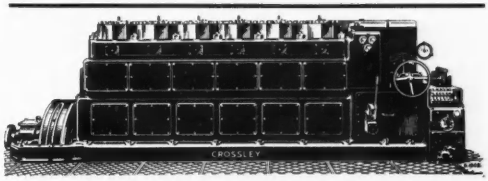
For applying the caps to the vials of penicillin, streptomycin, etc., Fords will be showing a fully-automatic cap-applier, which feeds aluminium caps down from a hopper holding a six hour supply, through an electronically-controlled chute, on to the vials. The output of the cap-applier exhibited is 8,000 vials per hour, and it is readily adjustable for vials of any size or diameter. Other cap-appliers in this range are available for lower outputs.

Also on show will be a Fords 3-head spinner, for automatically spinning the applied caps permanently on to the vials. The 3-head spinner has an output of 8,000 vials per hour, and others are available for smaller hourly outputs. In operation, the spinner is connected to the cap-applier by a short length of conveyor, so that the whole process of cap-applying and spinning is performed together. The illustrations show this vial capper and spinner.

During the past fifteen years, **Birlec Limited,** of Birmingham, have marketed " Lectrodryer " moisture removers for industrial applications. They have now developed and will exhibit a small unit to solve similar problems in strong-rooms, filing safes, muniment rooms, library store rooms, and similar locations. This standard equipment is known as the BE 40 Lectrodryer, and is capable of maintaining a space of 3500 cu ft at 50 per cent relative humidity (at 70° F), or 1750 cu ft at 35 per cent relative humidity.

The BE 40 is a compact unit, weighing about 500 lb, with overall dimensions of 26 × 43 × 38 in. high. It requires a normal commercial electric supply of 230 V and three or four air connections, depending on whether the unit is located inside or outside the space it is safeguarding. It is fully automatic and requires no maintenance attention.

Birlec " Lectrodryers " depend on the adsorbent qualities of activated alumina, which has the facility of taking up water vapour or other gases passing through it, and releasing this moisture when heated. The BE 40, therefore, contains two beds of alumina, one of which is used for drying, while the other is being reactivated. An automatic change-over mechanism ensures that the duties of the two beds alternate on a pre-determined control cycle. Heating for reactivation is provided by elements of nickel chromium wire, rated at approximately $2\frac{1}{2}$ kW.



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"HRN 6"	Marine Propulsion Engine	670 b.h.p.
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Also working models including Crossley-Premier 16-cylinder Horizontal vis-a-vis 2,625 b.h.p. engine.

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In this Climax Rock Drill and Engineering Works Limited's 'Maxam' Control Valve, efficient sealing of the piston is obtained by the use of Dowty 'O' Section Ring Seals. Despite constant passage across port faces these seals ensure reliable functioning of this air valve.

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A wide range of sizes are available and we shall be pleased to receive details of your specific requirements.

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NEWS OF THE MONTH

PERSONAL

Mr. C. T. Alderson, J.P., M.A.(Cantab.), contracts manager since 1945, has been appointed commercial manager of Ruston and Hornsby Ltd., Lincoln.

The directors of The Brush Electrical Engineering Co., Ltd., have agreed at the request of Simms Motor Units Ltd., to release **Mr. John Ayres,** at present managing director of Petters, Ltd., Staines, from his service agreements with the Brush Group, to enable him to take up the appointment of general manager and director of Simms Motor Units Ltd., on the 1st October, 1953.

Captain R. C. Petter, will as from that date be appointed managing director of Petters Ltd. Captain Petter, who is a member of the Brush Board, has agreed to assume these responsibilities on a temporary basis until it is possible for the Board to make a permanent appointment.

Mr. E. Bailey has been appointed general superintendent, South Works ; **Mr. E. Cook,** general superintendent, West Works ; **Mr. W. Edwards,** general superintendent, Finishing Shops ; **Mr. H. Holbeche,** superintendent, Tool Design and Manufacture ; **Mr. J. Oddy,** general superintendent in charge of Foundry and Engine Production ; **Mr. G. Gill,** Press Shop superintendent, of The Austin Motor Co. Ltd., Longbridge, Birmingham.

Mr. C. R. Bates, A.M.I.E.E., has given up his practice as industrial electronic consultant in order to specialise in electronic welding controls. He has been appointed a director of Bates & Bates Ltd., 73 Ashville Avenue, Birmingham 34, which company will be manufacturing synchronous controls to his designs and patents.

Mr. James Bennett, M.I.E.E., contracts manager of A. Reyrolle & Co. Ltd., Hebburn-on-Tyne, has been elected a director of the company.

Mr. D. Maxwell Buist, M.I.E.E., M.I.Ex., export director of the British Electrical and Allied Manufacturers' Association, 36/38 Kingsway, London, W.C.2, has been re-elected chairman of the Council of the Institute of Export.

Sir Sydney Camm, C.B.E., director and chief designer of Hawker Aircraft Ltd., has been elected President of the Royal Aeronautical Society, 4 Hamilton Place, London, W.1.

Mr. J. Y. Danks, B.Sc.(Eng.), M.I.C.E., has been appointed an executive director of Sir William Arrol & Co. Ltd., Glasgow.

Mr. H. Eckersley, M.I.Mech.E., M.I.Prod.E., general manager of the Wimet division of Wickman Ltd., Coventry, and **Mr. W. V. Hodgson, M.I.Prod.E.,** general manager of the firm's machine tool division, have been elected directors of the Company. A local board has been established, to which **Mr. R. J. Dixon,** chief engineer, **Mr. T. W. Hayes,** export sales manager, and **Mr. S. W. Perkins,** machine tool sales manager, have been appointed as special directors.

Major General W. J. Eldridge, C.B., C.B.E., D.S.O., M.C., has been appointed Controller of Supplies (Munitions) by the Minister of Supply in succession to **General Sir Kenneth N. Crawford, K.B.E., C.B.,** with effect from 1st October, 1953. Major General Eldridge will be granted the temporary rank of Lieutenant General on taking up this appointment.

Mr. O. W. Humphreys, B.Sc., F.Inst.P., M.I.E.E., director of the G.E.C. Research Laboratories, and **Mr. A. L. G. Lindley, M.I.Mech.E.,** general manager of the Fraser & Chalmers Engineering Works, have been appointed directors of the General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2.

Mr. Stanley Jones has been appointed general manager of the West Midlands Gas Board's Wolverhampton Division. He was formerly manager of the Middlesbrough Division of the Northern Gas Board.

Mr. F. N. Lloyd, chairman and managing director of F. H. Lloyd Ltd., James Bridge Steelworks, Wednesbury, has joined the board of N. Hingley & Sons Ltd., Netherton Ironworks, Dudley.

Mr. R. W. Mann, managing director of Victor Products (Wallsend) Ltd., Wallsend-on-Tyne, has been elected chairman of the Newcastle-on-Tyne Productivity Committee.

Mr. Thomas Millar has been appointed general manager of S. P. Austin & Son Ltd., Sunderland.

Mr. J. H. Page, A.M.I.C.E., A.M.I.Mech.E., has been elected to the Board and has been appointed technical director of Ruston-Bucyrus Ltd., Lincoln. **Mr. P. H. R. Durand, B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E.,** has been appointed chief engineer.

Mr. K. S. Peacock has been elected chairman of Guest, Keen & Nettlefolds Ltd., in succession to **Mr. J. H. Jolly,** who retired but will continue as a director of the company.

Mr. C. W. A. Priest, B.Sc.(Eng.), A.M.I.Mech.E., M.I.E.E., generation engineer (construction) of the Southern Division of the British Electricity Authority, has been appointed chief generation engineer (construction) of the South Wales Division, in succession to **Mr. T. H. Wood, M.I.Mech.E., A.M.I.E.E.,** who recently retired.

Mr. W. J. Richards, C.B.E., B.Sc., chief superintendent of the Telecommunications Research Establishment, Malvern, has been appointed director of the Radar Research Establishment. The two electronic experimental stations of the Ministry of Supply, at Malvern, will be amalgamated on September 1st and will then be known as the Radar Research Establishment.

Mr. E. G. Russell Roberts has been appointed a director of J. and E. Hall Ltd., Dartford, Kent.

Mr. S. A. Roberts, of Moor Hall Park, Sutton Coldfield, has been appointed general manager of the B.S.A. Tools Group of Companies.

Mr. Roberts is well known in Midland industrial circles as a Consulting Engineer. He is a member of a London firm of Industrial Consultants, and in this capacity he has been connected with some of the largest factories in the Birmingham area. In particular, he has had a long association with the General Electric Company, Witton. He is a Chartered Mechanical Engineer, a Member of the Institute of Industrial Administration, and holder of the Reed Gold Medal.

Mr. G. T. Shoosmith, M.A., M.I.C.E., M.I.Mech.E., M.I.Mar.E., has been appointed managing director of Plenty and Son Ltd., Eagle Iron Works, Newbury, Berkshire, in succession to **Mr. E. Gyles, M.I.Mar.E.,** who retired after nearly 50 years' service with the Company. **Mr. M. A. H. Walford, M.A., A.M.I.Mech.E.,** previously with Philips Electrical Ltd., has recently joined the firm.

Mr. J. A. Thomson has been appointed a director of Macrome Ltd., Wolverhampton.

Mr. P. E. Trier, M.A.(Cantab.), and **Mr. G. Knott, M.A. (Cantab.), A.M.I.E.E.,** have been appointed joint managers of the Research Laboratories of Mullard Ltd.

Mr. E. S. Waddington, F.S.E., A.M.(s.a.)I.Mech.E., M.Inst.W., Associate I.E.E., Associate (s.a.) I.E.E., of Philips Electrical Limited, Industrial Products Department, has again been elected to the Council of the Institute of Welding.

Mr. Ivan M. Waller, B.A., M.I.Mech.E., has joined The Lockheed Hydraulic Brake Co. Ltd., Leamington Spa ; he will be in charge of the Flexible Pipe and Self-sealing Couplings Division.

Major Noel E. Webster, O.B.E., M.C., has been elected President of the Institution of Mining Engineers, 436 Salisbury House, Finsbury Circus, London, E.C.2.

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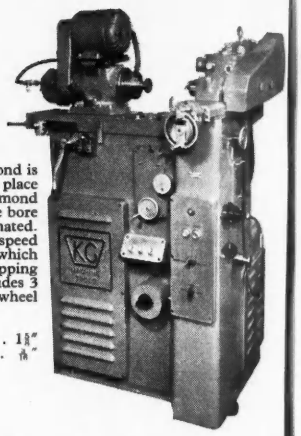

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Sir Harold West, Master Cutler, managing director of Newton Chambers & Co. Ltd., Sheffield, has accepted the position of chairman of the board of governors of Loughborough College, Loughborough, at the invitation of Miss Florence Horsbrugh, C.B.E., the Minister of Education.

Mr. J. Noel Wood, M.C., M.I.C.E., M.I.W.E., general manager of the Sheffield Corporation Water Works, has been invited to become a member of the board of the Faculty of Engineering of the University of Sheffield.

The Machinery Committee of the Organisation for European Economic Co-operation elected its officers for 1953/54.

Dr. Fritz Engelmann (German Federal Republic), Chef de Service of the Ministry of Economic Affairs, Bonn, succeeds Mr. Raymond Hugot (France), as Chairman of the Committee, and the new Vice-Chairman is Mr. Walter von Orelli (Switzerland), Chef de Service of the Association des Constructeurs Suisses de Machines, Zurich. Mr. Ristagno (Italy), Chef de Service of the Ministère de l'Industrie, Rome, was elected Chairman of the Technical Assistance Working Group.

MR. J. J. FRASER

Mr. James J. Fraser, managing director of Honeywell-Brown Limited, died at his home on Friday, July 17th, 1953, aged 51.

In 1928 he joined the Minneapolis-Honeywell organisation in Canada, where he became manager of the Montreal office. When, in 1936, a decision was taken to form the British Company of Honeywell-Brown Limited, Mr. Fraser was chosen for this work. As managing director since its inception, he has been directly responsible for its growth and development over the years.

During the war period, Mr. Fraser concerned himself particularly with navigational instruments for the R.A.F. and U.S.A.F. His energy, ability and foresight in this field were of inestimable value to the country.

BUSINESS NOTES

V. L. Farthing & Co. Ltd. have changed their address to 327/9, Tower Building, Water Street, Liverpool 1. Telephone: Central 9626.

The Owen Organisation of Great Britain has formed a company entitled Rubery Owen Canada Ltd. with offices at 1470 The Queensway, Postal Station N., Toronto 14, Canada. Mr. B. S. Male is the manager of the company which will handle the sales of member firms of the Owen Organisation.

Alley Consultants Ltd. is the name of a new company, formed at Burnham Market, Norfolk, to deal with the design and development of trailers and agricultural machinery. Mr. Eric Alley is managing director of the new company.

The Export Services Branch of The Board of Trade has moved to Lacon House, Theobalds Road, London, W.C.1 Telephone: CHAncery 4411.

Lectures on Corrosion. The Metallurgy Department of the Battersea Polytechnic, London, S.W.11, is arranging a course of eleven lectures dealing with corrosion. The lectures will be delivered at 7 p.m. on Thursday evenings from October 1st to December 10th. The fee for the complete course is 25s.

The Iron and Steel Board Headquarters are being equipped at Norfolk House, St. James's Square, London, S.W.1. Telephone: WHItehall 6931.

Babcock & Wilcox Ltd., Farringdon Street, London, E.C.4, announce the formation of a new joint company, Babcock Hitachi Kabushiki Kaisha, at Tokiwabashi Office, 5, 2-chome, Ote-machi, Chiyoda-ku, Tokyo, Japan.

The Woodall-Duckham Vertical Retort and Oven Construction Co. (1920) Ltd., have changed their name to Woodall-Duckham Construction Co. Ltd., 63/67 Brompton Road, London, S.W.3.

Rubery Owen Kepston Ltd., manufacturers of pressed steel pulleys for vee belts, have moved their organisation from Berkhamsted to the Pensnett Trading Estate, Brierley Hill, Near Dudley, Worcestershire.

Foire Internationale de Liege, the 6th International Trade Fair in Liege will be held from April 24th to May 9th, 1954.

Mr. F. Campus, Rector of Liege University, who is President of the Scientific and Technical Committee of the Fair, has now announced that the programme of the Fair will include special exhibitions and international conferences on the following subjects: Coal Gasification; Lubrication; Waterways and Inland Navigation; Water Treatment; and Heat Treatment of Metals.

Export of British Machine Tools to the Continent. Stanley Howard Ltd., 75/76 Exchange Buildings, Stephenson Place, Birmingham 2, announce that they are forming an organisation for the export and sale of British machine tools to Germany, Switzerland, France and other European countries. In Germany, an office has already been established in Cologne.

British machine tool manufacturers are invited to get in touch with Stanley Howard Ltd. who will be pleased to supply full details of the proposed organisation.

Monks & Crane Limited, Birmingham, announce that Mr. A. McCabe has been promoted to Scottish area manager and will be operating from the recently opened Glasgow office at 79, Crown Street, C.5.

The Midland Bright Drawn Steel and Engineering Co. Ltd., Brickhouse Lane, West Bromwich, have purchased the share capital of E. A. Godrich & Son Ltd., Wharf Street, Aston, Birmingham 6.

The British Standards Institution have moved to 2 Park Street, London, W.1. Telephone: MAYfair 9000.

Structural and Mechanical Development Engineers Ltd., 2 Buckingham Avenue, Slough, Buckinghamshire, have changed the name of the Company to S.M.D. Engineers Ltd. The firm is responsible for the construction work of the Almin Group.

The Association of British Chemical Manufacturers, 166 Piccadilly, London, W.1, announce that their new telephone number is HYDe Park 4126/7 and 1557/8.

New Dry Dock. Mr. J. W. Elliot, chairman of Swan, Hunter and Wigham Richardson Ltd., disclosed at the launching of the "British Merchant" that the company will build a new dry dock at Wallsend, which will be capable of accommodating oil tankers up to 45,000 tons.

GREAT BRITAIN'S AIRCRAFT INDUSTRY ON SHOW

More than fifty different types of aircraft—two thirds of them jets—will be on show at Farnborough from 7th to 13th September for the British Aircraft Industry's 1953 S.B.A.C. Flying Display and Exhibition. The Industry's test pilots will demonstrate all the latest aircraft in flight, including jet bombers, supersonic fighters, and research aircraft showing the last word in wing shapes and engines.

All three of the V-class jet bombers—the swept-wing *Valiant*, the delta-wing *Vulcan*, and the crescent-wing *Victor*—will be there. The latest models of the *Hunter* and *Swift* jet fighters will be flying.

Two all-weather radar-carrying fighters will be demonstrated—the delta-wing *Javelin* being built for the Royal Air Force, and the de Havilland 110, now under development for the Royal Navy.

New examples of the British approach to the guided missiles of the future will be there for inspection on the ground.

Britain's trio of turbine-engined airliners—the *Comet*, *Viscount* and *Britannia*—will be flying. The *Britannia* shown will have the latest engine installation. The *Heron* 2 will also be flown.

It is expected that new helicopters under development for passenger service will be flying. These types have short stub-wings as well as the overhead rotors. Revolutionary types of helicopter turbine powerplants will be seen.

Because of the growing importance of commercial aviation to Great Britain, one whole day of the Display, Thursday, is being devoted to special demonstrations by civil types only.

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The production version of the large *Beverley* freighter, which is being built for the Royal Air Force, will be there, so will an ambulance version of the Prestwick *Pioneer*, the ultra short-landing communications aircraft.

There is a visitor from Canada, the *Beaver*, which is built by de Havilland there. A model powered by the British *Leonides* piston engine will be flown.

Among the research aircraft will be delta-wing machines and the Short *SB-5* which has an adjustable swept-wing which can be swept at extreme angles.

There will also be experimental test beds flying with the latest jet engines.

The great Exhibition Hall will be filled with the stands of over 200 exhibitors, showing complete engines, working models, and all the thousands of parts and accessories which go into the modern aircraft. There will also be models of some of the new British aircraft being projected for the future, now still at the drawing board stage.

ADMIRALTY SHIP WELDING COMMITTEE REPORT

A limited number of copies of the " S.S. 'Ocean Vulcan' Sea Trials, Report No. R.8," prepared by Mr. F. B. Bull, M.A., B.Sc., and published by Her Majesty's Stationery Office for the Admiralty Ship Welding Committee, are available for loan or scrutiny in the Department of the Chief of Naval Information, Admiralty.

This Report is one of a series of investigations into a comparison of the structural behaviour of welded and riveted ships under the forces experienced at sea. The Report covers measurements made on S.S. " Ocean Vulcan," a welded tramp vessel of 7,174 gross tons, during sixteen crossings of the Atlantic from December, 1945-May, 1947.

The Report, which is one of 175 pages with tables and figures, refers to ocean waves, earlier measurements of strain at sea, planning of sea trials on the "Ocean Vulcan", instrumentation, voyages undertaken and a discussion of the data obtained and methods employed.

Application should be made personally to the Department of the Chief of Naval Information, Admiralty, Whitehall (Room 23 West Block Ground).

The Gold Coast Government is to send an important delegation of Ministers and Members of the National Committee for the Volta River Project to Canada in September. The party will inspect installations for the production of power and aluminium, to assist them in their work in connection with the Volta project.

The delegation will be headed by Mr. K. A. Gbedemah, Minister of Commerce and Industry.

They will spend several days visiting plants belonging to the Aluminium Company of Canada, both in operation and under construction.

On September 23, the party will return to the United Kingdom; it is hoped that they may be shown various aspects of British aluminium production, and one of the large scale projects being carried out under the supervision of Sir William Halcrow and Partners, consulting engineers to the Volta River Project.

Fraser and Chalmers Engineering Works of The General Electric Co. Ltd., Erith, Kent, are to supply two of their new side discharging, weighing type Wagon Tipplers to the South Durham Iron and Steel Company through Ross Engineers Limited.

The Tipplers will be of special design for weighing and tipping wagons of 60 tons gross load, but in this instance will handle ore wagons containing a maximum of 31 tons and will have a gross weight not exceeding 45 tons. The design of the motors and worm reduction gears will be based on this maximum design loading of 45 tons.

The drive for one machine will be provided by an a.c. 85 hp 730 rpm totally enclosed fan-cooled slip-ring induction type motor, while the drive for the second machine will be provided by a modified Ward-Leonard system to enable the 110 hp 500 rpm d.c. Mill-type Tippler motor and the Ross wagon haulage motors to be operated from one set.

The tipping action of the machines will be fully automatic and no clamping or binding devices are required for holding the wagon to the rails when in a tipped position. The proposed capacity range of the two machines is that one should discharge a total of 20 wagons per hour equivalent to 490 tons per hour from 24½ ton capacity wagons; while the other will discharge 32 wagons per hour equivalent to 784 tons per hour from 24½ ton capacity wagons.

The hoisting gear will be electrically controlled and operations are regulated by a series of push button switches covering every phase of the machine's activities. One operator only is required for each machine.

"Nimoply 75"—An Improved Sheet Material for High-Temperature Uses. The high-strength, high-temperature alloy, developed under the name of Nimonic 75, has been widely used in sheet form for the combustion chamber linings in many British gas turbines. In this type of service the chief requirements of the metal are strength to resist distortion and cracking through the stresses arising from thermal expansion, plus high resistance to scaling. Nimonic 75 fulfils these needs to an adequate degree and, in addition, readily lends itself to normal fabricating, including argonarc and resistance welding.

For some time, work has been going on to develop a material which would have the characteristic properties of Nimonic 75 but, at the same time, would have a much higher heat conductivity in order to dissipate the heat of the combustion in the chamber more quickly and secure a much more even temperature distribution in the chamber. Under the registered trade mark " Nimoply 75," Henry Wiggin & Co. Ltd., now announce the introduction of composite metal sheets, having Nimonic 75 on both sides of a copper base.

This metal sandwich is produced by rolling copper between sheets of Nimonic 75, resulting in a clad sheet having many potential uses, not only in gas turbine construction but also in other fields of high-temperature engineering.

MULLARD FILMSTRIPS FOR ORDINARY NATIONAL CERTIFICATE COURSE IN ELECTRICAL ENGINEERING

A series of twenty filmstrips, covering the two final years in the Ordinary National Certificate Course in Electrical Engineering, has recently been produced by the Technical Publications Department of Mullard Ltd. It is understood that these filmstrips are the first of their kind to be produced to cover a specific course of study. Although prepared primarily for the assistance of lecturers and teachers in technical training establishments, many of the strips will undoubtedly be found suitable for senior science classes in Grammar Schools and for staff and apprentice training.

In producing this new series of filmstrips the Mullard Company have had the advice and assistance of an Advisory Panel composed in the main of teachers in Technical Colleges. The strips were made and will be distributed by Unicorn Head, Visual Aids Ltd.

Teaching notes are provided with each strip. In preparing these notes no attempt has been made to produce " potted " text books or to impose on the lecturer any preconceived method of exposition. In general, the notes are confined to brief statements of the principles illustrated and to short descriptions of the apparatus shown.

The majority of the illustrations are either in the form of diagrams, graphs and the like to illustrate principles and methods of construction; or drawings and photographs showing equipment under construction, examples of modern apparatus and typical installations. In selecting the diagrams, care has been taken to avoid the obvious and those of the simpler type that can be easily drawn on the blackboards. Instead, the tendency has been to concentrate on diagrams that would normally involve laborious blackboard work, and on graphs where a greater degree of accuracy is required than can be obtained by free-hand drawing. In selecting drawings and photographs of equipment etc., the object has been to introduce to the student, at an early stage, the practical applications of the principles taught.

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BRITISH FIRMS AT AUSTRALIAN ROCKET RANGE

More British aviation firms are setting up branches and depots in Australia for work connected with the Guided Weapons Range at Woomera.

The English Electric Company is opening workshops in Salisbury, South Australia, for the assembly of guided missiles which will be tested on the Woomera range. The manager of the Company's Weapons Division has arrived in Australia to set up the new establishment. English Electric have contracts to build a number of guided weapons, and have already built a two-stage rocket which has been fired on the Aberporth range on the west coast of Great Britain.

Another company, Bristols, is starting a depot at Salisbury to support its activities on the Woomera range. Bristols have already tested several ram-jet vehicles which are being used for research into future types of guided weapons.

Faireys have also sent technicians to Woomera to test their model pilotless rocket-powered experimental aircraft using the vertical take-off (VTO) technique, and the company plans more tests for the future.

Some time ago it was announced that the Armstrong Whitworth Company, member of the Hawker Siddeley Group, was setting up its own test centre for rockets and guided missiles at Salisbury. A factory is to be equipped entirely for work on rockets and guided weapons, as well as a range for " shooting tests into the stratosphere, ionosphere and beyond." The General Electric Company, too, is setting up a unit at Salisbury for the development of equipment for guided weapons.

Salisbury has been chosen by these British firms because it is a small town conveniently placed 300 miles from Woomera and not far from Adelaide. Altogether more than 100 British companies are participating in the projects.

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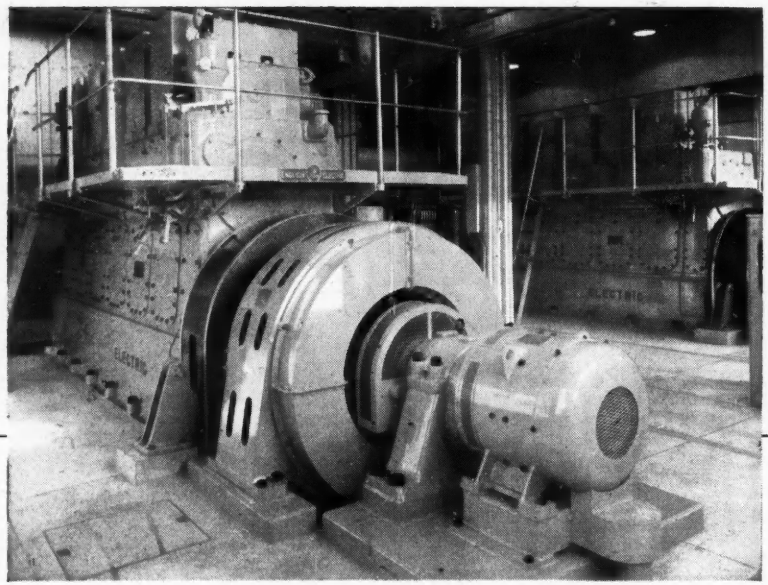

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